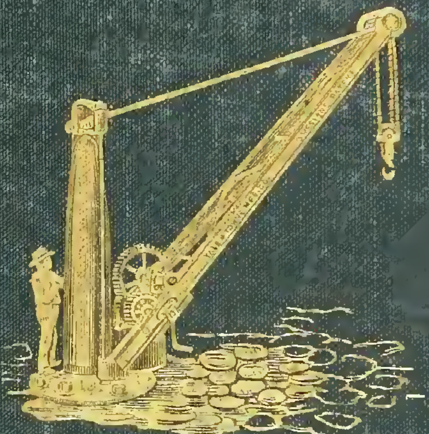
A Treatise on Cranes.



Henry R. Towne.

A TREATISE ON CRANES.

A TREATISE

ON

CRANES.

DESCRIPTIVE PARTICULARLY OF THOSE DESIGNED AND BUILT BY
THE YALE & TOWNE MANUFACTURING CO.,
OWNING AND OPERATING
THE WESTON CRANE CO.

INCLUDING ALSO A DESCRIPTION OF LIGHT HOISTING MACHINERY
AS BUILT BY THE SAME MAKERS.

BY
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PREFACE.

The subject of Cranes has had but little consideration from technical writers, and has never yet received from them the attention which its importance in the mechanic arts will justify. It is perhaps partly due to this cause that the value and economy of Cranes, as labor-saving machines, is as yet so little appreciated in this country.

The only English books descriptive of Cranes are that of Glynn, written more than thirty years ago, and the catalogues published by various English firms to advertise their products, none of which fully represent what is best in English practice, or affords any information as to the important details of construction embodied in the machines they illustrate.

The present treatise, although intended primarily to place before users of Cranes a description of those built by The Yale & Towne Manufacturing Company, includes a careful study of the subject from an independent point of view, and will, it is believed, be found of interest to engineers generally by reason of its comprehensiveness, both as relates to the various types of Cranes and to the details of their construction, and because it carries the art it describes down to a more recent date than

any previous publication. In its description of details and of actual construction, it embodies the results of the combined work of several skilled inventors and mechanical engineers, continued uninterruptedly, under the author's direction, during a number of years and applied, together with the resources of a large establishment, to the study and development of the art of Crane building as a distinct specialty.

It is the first publication descriptive of American, as distinct from European practice, in the specialty of which it treats. The class of machines which it describes has long been recognized in Europe as one of wide importance and interest. It is the purpose of this treatise to indicate to American readers the great variety of uses to which Cranes can be applied with economy and convenience, and to describe the latest and best results of American practice in this field of engineering work.

H. R. T.

September, 1883.

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PART I.

PART I.

INTRODUCTION.

The contents of this Part consist of a general survey of the subject of Cranes, including an enumeration of the principal forms in which they are used, a definite system of nomenclature applied to the various forms, and finally a study of the most important elements of mechanism employed in Crane construction.

The latter portion is in some measure a record of the processes of reasoning and selection which resulted in the adoption of the forms of details employed in the Weston Cranes. In undertaking this new field of work the builders of these Cranes were untrammeled by any previous position or bias as to the details of the work, and many months of careful study were given to the consideration of the best forms to be adopted. The process usually resorted to in this effort was to give equal consideration to all possible plans and to select therefrom the one which gave the best promise of satisfactory results. The decisions thus reached were then subjected to the test of practice, and further modifications and improvements were introduced as experience was gained. The effort throughout was to reach the best practicable result, and to determine finally and reliably the best form or method of construction for each of the important details of Cranes.

The following pages, therefore, are not immediately descriptive of the Weston Cranes, but comprise a preliminary review of the whole subject which will enable the reader to understand the reasons upon which the selection of the chief elements in the Weston Cranes are based, and will assist him in judging for himself as to the soundness of the conclusions reached in the succeeding parts of this book.

CRANES;

A STUDY OF TYPES AND DETAILS,

BY

HENRY R. TOWNE.

A paper read before the American Society of Mechanical Engineers, at the Cleveland meeting, June, 1883.

In the study of any special class of machines it is often conducive to a better understanding of the subject clearly to enumerate the several types or forms in which the machine is used, and also to consider each of its more important details separately, rather than in their combination with other elements of the mechanism. It is proposed in the following pages thus to treat the subject of Cranes.

The only English text-books descriptive of cranes are Glynn's, which treats of English practice in crane building as it existed more than thirty years ago, and sundry catalogues published by English dealers in machinery as a means of advertising the products of the various builders of cranes for whom they act as selling agents. The practice represented in the former is now almost obsolete, by reason of the improvements which have been effected, and the latter consist of little but a series of pictures of various cranes, without descriptive text, and with no information as to the details of their construction.

The building of cranes has long been recognized in Europe as one of the most important subjects in the field of mechanical engineering, and cranes of many forms are there seen applied to an almost infinite variety of uses. In America, on the contrary, cranes are but little used or appreciated, in comparison, at least, with the extent of their application in European countries. It is

the purpose of this paper to present to American readers a brief classification and description of the most important types of cranes, and a similarly brief study of the more important elements entering into their construction, the object of the latter inquiry being to determine, if possible, the best forms of elements to be adopted.

With a better knowledge of crane construction will surely come a better appreciation of their economy and value as labor-saving machines. In hundreds of mills and workshops heavy material is now being moved and handled by manual labor at an expense so much in excess of the cost of doing the same work far more rapidly and conveniently by cranes, that the saving effected by the latter would yield an annual profit of from twenty to fifty per cent. upon their first cost, while in many cases this outlay would be entirely repaid by the economy of one year's use.

CLASSIFICATION OF CRANES.

A *hoist* is a machine for raising and lowering weights. A *crane* is a hoist with the added capacity of moving the load in a lateral or horizontal direction.

All cranes, therefore, are provided with hoisting mechanism, and, in addition, must be capable of moving the load in one or more horizontal directions. This second function is effected in some types of cranes by simply pushing the suspended load, in others by the operation of a distinct mechanism.

Cranes are most clearly classified by reference to their modes of transferring their loads horizontally; and, thus considered, are found to divide themselves into the following groups, viz.:

1. *Rotary*—In which the load is revolved around a fixed center, such as a mast or column.

2. *Rectilinear*—In which the load is moved in straight lines, in one or more directions.

Both types of cranes are subdivided into two general classes as to their movements, viz.:

(*A*.) *Fixed*—When their supporting members are fixed in some permanent location.

(*B.*) *Movable*—When the crane as a whole can be moved about.

And into four other general classes as to their source of motive power, viz.:

(*a.*) *Hand*—When the motions, either vertical or horizontal, are effected by manual power.

(*b.*) *Power*—When the motions are effected by power derived from line shafting driven by a stationary engine or other fixed motor.

(*c.*) *Steam*—When the motive power is derived from a steam engine attached directly to the crane itself and moving with it.

(*d.*) *Hydraulic*—When the motive power consists of hydraulic pressure obtained from a pump or accumulator, and carried to the crane by pipes.

A further distinction is covered by the term locomotive, which is applied to cranes (usually of the rotary type) which are capable of propelling themselves upon a roadway or track.

Rotary cranes comprise the following principal types, viz.:

1. *Swing Cranes*—In which the central mast is pivoted to the floor and roof of the building, and the load is suspended from a block fixed at the outer end of an arm projecting horizontally from the mast, the only horizontal motion being one of rotation.

2. *Jib Cranes*—In which the central mast is pivoted to the floor and roof of the building, and the load is suspended from a trolley traveling in and out upon an arm or jib projecting laterally from the mast.

3. *Column Cranes*—Which consist of a jib crane constructed to revolve around or upon a fixed column forming the support of a building or floor.

4. *Pillar Cranes*—In which the central column or pillar is entirely supported by a heavy foundation built at its base, and the load is suspended from a boom projecting from the pillar and revolving with it or around it.

5. *Derrick Cranes*—Which consist of a jib crane for yard use, the upper end or pivot of the mast being held in position by guy-rods or stays, instead of by attachment to a roof or ceiling.

6. *Walking Cranes*—Which consist of a pillar or jib crane

mounted on wheels, and arranged to travel by power or by hand upon one or more rails.

7. *Locomotive Cranes*—Which consist of a pillar crane mounted on wheels, and provided with a steam engine and boiler, the power of which is available for operating the crane and for propelling it upon its tracks.

Rectilinear Cranes comprise the following principal types:—

1. *Bridge Cranes*—In which a fixed bridge spans an opening, and the load is suspended from a truck or trolley capable of moving across the bridge.

2. *Tram Cranes*—In which a truck or short bridge, from which the load is suspended, is arranged to travel longitudinally upon a pair of overhead rails, but is without capacity for transverse motion.

3. *Traveling Cranes*—In which a rectangular space is provided with overhead tracks upon two of its opposite sides, and is spanned by a bridge arranged to travel longitudinally upon these tracks, the load being suspended from a truck or trolley capable of moving transversely across the bridge, so that the load may be moved to or from any point within the entire rectangle.

4. *Gantries*—In which an overhead bridge is supported at each end by a frame, or trestle, extending downwards, and having wheels in its base to permit of travel upon two longitudinal tracks laid upon the ground, so that the entire structure can move endwise upon the latter, and the load, which is suspended from a truck or trolley on the bridge, can be moved transversely across the bridge.

5. *Rotary Bridge Cranes*—Which combine a rotary with a rectilinear movement, and consist of a bridge having one end pivoted to a central pier or post, while the other or outer end travels on a circular overhead track, or is supported by a gantry frame traveling upon a circular track upon the ground, the load being suspended from a truck or trolley traveling transversely across the bridge.

The above nomenclature will be adhered to in the following descriptions of crane construction.

CRANE DETAILS.

HOISTING GEAR.

The most important factor in the economy and convenience of a crane is the mechanism by which the load is lifted and lowered, as it must necessarily come into action every time the crane is used.

In all applications of power, from whatever source derived, it must be remembered that the gearing of a machine can only modify the power applied in one of two ways, viz.:

(1). By reducing its velocity, and proportionately increasing its force or "pull."

(2). By increasing the velocity, and proportionately decreasing the intensity of the power transmitted.

Under no circumstances, unless the motive force is increased, can power be gained except by a sacrifice in speed, or can speed be increased, except by a sacrifice in power. If either or both must be increased without diminishing the other, it can only be accomplished by supplying more motive power.

The function of gearing, then, is to change the force or direction of the power applied. If it is well designed and constructed, this may be done with only a small loss from friction; while, if badly made, the gearing may absorb much power in wasteful friction of its moving parts.

In machinery for hoisting, the "purchase" or conversion of velocity into lifting power, is usually effected partly by a multiplication of the ropes or chains of the tackle through which the load is suspended, and partly by gearing within the machine, which latter thus becomes an important feature in crane work. The gearing ordinarily used for this purpose consists either of spur wheels and pinions or of worm wheels and worms, or both combined, and the smoothness and economy of power of the machine depend largely upon the manner in which the gearing is made.

A second feature of prime importance in the hoisting gear of a crane is the mode of sustaining the load, and guarding against its "running down" when the application of the motive power is discontinued. This has heretofore been accomplished, in machines having spur gearing, by a ratchet-wheel, the pawl of which has to be entirely disengaged to permit lowering to occur, or by a brake, which, when on, prevents all motion of the machine, and which requires to be held or thrown off, both in hoisting and lowering. In machines having worm gearing, the end is attained by a construction of the worm wheels such that the friction between the worm and the wheel is sufficient to prevent the backward rotation of the worm under the pressure of the teeth of the worm wheel caused by the load, the resistance thus generated sufficing to prevent the running down of the load.

The worm-wheel system is usually safe against accidents, but is not economical of power if the worm gears are proportioned, as above explained, to hold the load suspended without running backwards when the application of power ceases, as is usually the case. The spur-wheel system, on the other hand, is a constant and inevitable source of great danger, both to the load and to the operator. With the least carelessness in lowering, the load begins to descend with great velocity, and the mechanism is driven backwards with corresponding speed and violence. If not checked the load then practically falls as if unsupported. If too suddenly checked, violent strain is thrown upon the entire frame of the crane and on its gearing, which latter is thus liable to damage, and even to "stripping" or fracture, in which event the load falls. Where spur-geared cranes are operated by hand this "running down" of the load involves a reversing or "flying back" of the cranks, which then frequently strike the men before they can escape beyond their reach. Accidents of this kind, resulting in injury to limbs, and even to life, are constantly happening with common cranes, and are reported almost daily in the newspapers.

It is possible, however, so to proportion worm gearing as to place it almost, if not wholly, upon a parity with spur gearing in regard to economy of power transmitted, and, by the use of cut

worm wheels, driven by turned worms or pinions (the teeth of the wheel being formed by means of a chasing hob or cutter), so to construct worm gearing that it becomes the best and most convenient form of gearing for use in crane mechanism. It is found that gearing thus made will not automatically support the load, and that the latter, if left suspended, will drive the worm gearing backward, but in this case the descent of the load is quite slow, and no perceptible acceleration takes place, so that the worm gears thus act as a governor to control the load. By the application of a small brake to the worm-shaft this tendency is counteracted, and, by connecting this brake with the levers which control the motions of the mechanism, the brake is easily made automatic, and thus securely holds the load whenever the crane mechanism is at rest.

In all cranes, except those of small size, provision should be made for one or more changes of speed in hoisting and lowering, so that the speed may be varied according to the load and the nature of the work to be done. Cranes operated by power *may* be so constructed that the maximum load can be lifted at the quickest speed; but they are usually so proportioned that this can be done only at a slow speed. By this plan much economy of gearing, space and cost is effected, and the practical efficiency of the crane for all ordinary uses is not impaired. The most perfect construction is one that permits a change of speeds to be made whether the hoisting gear is in motion or at rest, and which sustains the load automatically while a change of speed is being made.

The hoisting gear of a crane should therefore attain the following results, viz.:

(1.) Such changes in direction and velocity of the power applied as will give the desired motions to the load.

(2.) The accomplishment of this with a minimum loss of power through friction.

(3.) The safety, both of the operator and the load, under all conditions; to insure which the load must be always self-sustained and incapable of "running down."

(4.) Capacity for changes of speed and for convenient transition from one of these to another at will, whether the gearing is in motion or at rest, and for the automatic support of the load during the act of changing speeds.

TRAVERSE GEAR.

In this, as in the hoisting gear, good design and construction are essential to economy of power, and frequently to safety against accidents.

In some types of rotary cranes no traverse mechanism exists, except an arrangement of parts which provides for the rotation of the crane. In others, such as jib and derrick cranes, provision must also be made for moving the truck or trolley horizontally on the jib, and the same provision is required for moving the trolley of bridge and traveling cranes transversely on the bridge. In all such cases a separate mechanism, distinct from the hoisting gear, has heretofore been employed, and is still sometimes desirable or convenient. When employed, its parts should be as few and simple as possible, and it should be so far independent of the hoisting gear as to permit either to be used at any time separately or conjointly. In power cranes provision should be made for accelerating the speed of the trolley travel whenever the nature of the work admits of it. The best possible result is attained when travel of the trolley is effected without varying the vertical position of the load, and without causing useless movement of the hoisting chain or rope over the sheaves through which it supports the load, which movement would involve much additional friction, and cause rapid wear of the chain or rope.

In traveling cranes a point of great importance is the parallelism of the bridge travel with the longitudinal tracks. Any defect here results in increased resistance to traction, and any considerable error might cause derailment. In traveling cranes, as heretofore built, the use of flanged wheels has been relied upon to prevent derailment, and the propulsion of the bridge has been effected by a transverse shaft extending the whole length of the bridge, and connected by gearing with the truck-wheels sup-

porting each end of the bridge, so that, by revolving the shaft, the truck-wheels would be rotated, and the bridge be thereby propelled, provided the adhesion between the wheels and the rails was sufficient. In some instances, where the adhesion has not been sufficient to prevent slipping, a cast iron rack has been laid adjacent to the longitudinal tracks, and extending their whole length, and pinions, gearing into this rack, attached to the axles of the truck-wheels, so that propulsion is effected independently of the adhesion of the truck-wheels to the track. If the load were always central on the bridge, and the motive power always applied to this shaft at the center of its length, this plan would answer well, although it is somewhat clumsy ; but in practice the load is constantly varying in position, and the motive power is applied at one end of the long transverse shaft, so that torsion of the shaft induces a considerable variation in the travel of the opposite ends of the bridge. This error is a constantly varying one, according to the portion of the load resting upon each truck, as determined by the position of the trolley, the load being never equally distributed between the two trucks except when it is exactly in the center. It follows, therefore, that this system of bridge travel, although operative, is radically defective, and that its use involves a constant loss of power by needless friction, and entails a proportionate amount of wear and tear of rails, wheels, and driving gear.

A better and more simple method of bridge propulsion has lately been introduced, by means of which the longitudinal motions of the bridge are effected by *pulling* each of its ends, simultaneously and at equal speed, in the desired direction. For this purpose light wire cables are used which, by a very simple and ingenious arrangement of guide sheaves, are made to act as a "squaring device" to hold the bridge at all times perpendicular, or square, to the tracks upon which it travels. By this system the friction of traction is reduced to a minimum, and the danger of derailment from unequal travel of the opposite ends of the bridge entirely obviated.

From the above facts it becomes evident that a perfect system of bridge propulsion must hold the bridge always absolutely

square with its tracks, and must propel the opposite ends of the bridge in the same direction, at the same time, and at the same speed, however unequally the load may be distributed. It is desirable also that, in large cranes at least, provision be made for starting the bridge slowly from a state of rest, and then increasing the speed, and also for varying the speed while the bridge is in motion.

CHAINS *versus* ROPES,
AND
CHAIN WHEELS *versus* DRUMS.

In almost every type of crane the load is primarily carried upon a flexible cord of some kind. This usually consists of rope, either hemp or wire, or of chain. Each of these has distinctive merits and objections.

Ropes have the advantage of being formed of many parts or fibres, so that no splicing or welding is necessary in their manufacture; and they thus have an assured and practically uniform strength throughout their length.

Chains, on the contrary, consist of a series of independent links, each of which is formed from a straight bar, and welded, so that a single imperfect weld injures the whole, the strength of a chain being obviously limited by the strength of its weakest link. By care and good workmanship, however, this danger can be avoided, in which case the chain becomes as safe as the rope, and much more durable.

Where a rope is used, the hoisting gear must necessarily include a drum or barrel upon which the rope is wound up when hoisting takes place. Chain may also be thus wound up on a barrel, and this has heretofore been the common practice when chains have been employed in crane construction, and a prominent feature in cranes of large capacity has usually been a proportionately large "winding-barrel" to receive the chain. A chain, however, admits of another mode of construction, which consists in substituting for the wide barrel or drum a pocketed "chain-wheel," consisting

of a narrow wheel or sheave, of a width only slightly greater than that of the chain, and having formed upon its periphery a series of indentations or "pockets," exactly corresponding in size and shape with the links of the chain, so that the chain and the pockets fit together accurately, and slipping of the chain upon the chain wheel becomes impossible. It thus follows that rotation of the chain wheel causes positive motion of the chain at a speed equal to the circumferential velocity of the wheel, in a manner precisely similar to the motion of a rack driven by a pinion, or of one spur wheel driven by another.

To be used in this way, it is necessary that the chain should have a constant and uniform "pitch," that is, that every link should be exactly alike, so that the distance from link to link shall be always the same (just as in spur gearing the spacing, or pitch, of the teeth must be uniform), and also that the pitch or spacing of the pockets of the chain wheel correspond accurately with the pitch of the chain. If this be done, and if the chain have a cross section of such area that, when carrying the full load, it is not strained to its elastic limit, or to a degree which will cause any permanent elongation of its links, then a chain may be thus used, in engagement with a pocketed chain wheel, as well and as safely as on a barrel. Indeed, a properly shaped wheel of this kind is much easier on the chain than a winding barrel or drum, for the reason that the latter has a cylindrical surface, while the bearing face of the former is not cylindrical, but polygonal, the bed or bottom of each pocket being tangential to the radius at its centre, and so presenting a flat surface for the parallel sides of each alternate link to bear upon. When the chain is wrapped upon a cylindrical barrel, on the other hand, the straight sides of every alternate link, being tangential to the surface of the barrel, can each touch it at one point only, the link being unsupported throughout the rest of its length, and the tendency of the strain induced by the load is to bend each of these links to the contour of the barrel. This effect may be easily seen in any chain which has been wrapped, under severe strain, upon a cylindrical barrel, unless the diameter of the barrel be very large. The spriral grooving of a barrel does not remedy this fault, although it affords

a much better bearing for the chain than a plain cylinder, which latter is only permissible for small chains and light loads.

For heavy cranes hemp ropes are rarely used owing to the size and multiplicity of parts required, and to their rapid wear. They are also inadmissible where liable to be exposed to much heat as, for instance, in a foundry. Wire ropes are more available, and are often employed, but these also wear rapidly unless the sheaves and barrels around which they pass are of large diameter, while this requirement, if met, reduces the effective height of hoist and necessitates more parts or gearing to obtain the necessary purchase, and augments the bulkiness of the machine. Either material involves resort to a large winding barrel or drum.

The usual and best device for large cranes is well made chain, and this, when used with pocketed chain wheels and sheaves, gives the best and most satisfactory results, and leaves nothing to be desired. The adoption of this plan dispenses with winding barrels, preserves the shape, and therefore the durability, of the links of the chain, and in every way simplifies and compacts the mechanism.

The relative merits of the several systems may now be summed up as follows :

(1.) *As to the Sustaining Cord.*

Hemp Ropes.—Admissible only for small cranes not in frequent use and not exposed to the weather or to heat.

Wire Ropes.—Available under any ordinary conditions, but involving a winding barrel of large diameter and large sheaves ; not economical of space.

Chains.—Possessing, if well made, all advantages and the greatest durability : *common chain*, requiring a winding drum, but permitting it and the sheaves to be of smaller diameter than with wire rope ; *pitch chain*, dispensing with a drum and admitting of the use of a narrow chain wheel.

(2.) *As to the Winding Device for Hauling in and Paying Out the Rope or Chain.*

Winding Drums or Barrels.—These must have a diameter and length such as will enable them to receive the whole length of rope or chain to be hauled in by winding it upon their surface in one coil, without overlapping. In large cranes the load is usually carried upon four, six, or even eight parts of rope or chain, so that the length to be wound up amounts to four, six, or eight times the effective hoist, and the dimensions of the barrel thus become very large. Moreover, this barrel must either be caused to travel longitudinally on its shaft, so that the rope or chain as it leads off shall be always in the center of the crane and hoisting mechanism (which method of construction involves serious complication and greatly widens the space occupied by the gearing), or the rope or chain, as it uncoils, be permitted to vary in position from one end to the other of the barrel, in which case it is nearly always out of center, thus inducing objectionable lateral strains and causing greater friction and wear.

Chain Wheels, with Pockets.—These require a width only slightly greater than a single part of the chain, and a diameter merely sufficient to give the proper engagement with it, so that both dimensions become much smaller than in a winding barrel, and the total space occupied is but a small fraction of that required for the latter device. The *chain wheel* is fixed in direct line with the chain, and all lateral strains are avoided, while the flat bearings afforded for the chain by the pockets preserve the shape of the links and protect them from bending strains. The slack chain, after passing over the wheel, falls into a proper receptacle below.

From this analysis of the facts is deduced the proposition that chains, if well made, constitute the best form of flexible cord for sustaining the load in a crane, and that a well constructed *chain wheel* (as contradistinguished from a winding barrel) is the best form of device for hauling in and paying out the chain; and therefore, that the best method of crane construction involves the use of these two elements.

TROLLEYS AND TRUCKS.

The trolley of a crane is the movable carriage from which the load is immediately suspended and by which longitudinal motion of the load upon the jib, or the bridge, of a crane is effected. The term truck is usually restricted to the wheeled carriage used to support each end of the bridge of a traveling crane, or the corresponding part of rectilinear cranes of all kinds. Rectilinear cranes require usually at least one trolley, and one or more trucks. Rotary cranes require usually a trolley only.

The whole load of a crane is hung primarily upon the trolley, and where trucks are used, is transferred in full to them, together with the weight of the crane itself. It is desirable, therefore, that these parts should not only possess ample strength to resist the strains they may be subjected to, but also that they be so arranged that any yielding or breakage of their parts will not allow the load to fall to the ground, but only permit it to descend until the supporting beam rests on the rails upon which the trolley or truck is to travel. For this reason the construction should be such that the ends of the bridge, in traveling and similar cranes, overlap the longitudinal tracks, and the axles or housings of the trolley, in cranes of all kinds, overlap the rails upon which it runs. It is further desirable that the vertical distance between these overlapping parts and the rails be as small as possible, so that, in the event of any break occurring, the distance through which these parts pass before being arrested is so small that no serious shock can ensue. With careful designing this distance can be reduced to merely the necessary clearance of the parts, which need not exceed more than one inch or less.

A natural preference exists for wrought iron rather than cast iron as the material from which to construct the moving parts of a crane; and, unquestionably, it is always best to use wrought iron for parts that are to be exposed to tension under heavy loads. Cast iron, however, is the better material for those parts that are subject to compression, and by skillful designing it is usually possible so to arrange the parts of trolleys and trucks as to use cast iron wherever stiffness or resistance to compression is

required, while still employing wrought iron for the parts under tension. In this way the greatest economy is attained, and not unfrequently a better result secured than by the use of either material alone.

The wheels, both of trolleys and trucks, should be true cylindrically, should be double-flanged, and, by preference, should have chilled treads. If wheels of small diameter are used, in order to economize height, they should be provided with anti-friction bushings, to counteract the increased resistance to traction caused by their small diameter. The wheel-base, or distance from center to center of the adjacent wheels, should be as large as possible, in order to avoid cramping between the rails, and to facilitate the easy motion of the carriage upon its track. In large traveling cranes it is desirable that the axles of the truck-wheels be supported in spherical bearings, so that the wheels may adjust themselves to any yielding of the track which may result from the passage of heavy loads, and thus all unnecessary straining of the parts of the truck be avoided.

FRAMES AND GIRDERS.

In the early building of cranes, timber was chiefly used in the construction of their frame-work, and is still much employed in this country. Improvements in the manufacture of structural irons, and the large variety of shapes now obtainable, have, however, greatly altered the relative cost of construction in timber and iron, and made it possible to employ iron much more largely than formerly.

Experience in the practical designing and building of cranes of many types has convinced the writer that, by the proper use of materials, crane construction in iron costs, in most cases, little, if any more than in wood. For example: The frame of an ordinary jib crane consists of three principal members—the mast, the jib, and the brace. If of iron, each of these consists of a single piece or bar, or, in larger cranes, of two parallel pieces, and the union of these several members at their intersections is accomplished simply and very economically. If timber be used, on the other hand,

more or less trussing is required, except for small cranes; and many bolts, washers and castings are necessary to provide for the proper bearing of one part upon the other and to securely fasten the several parts together. The iron frame when once properly put together is practically imperishable. If properly painted it will not deteriorate, nor is it affected by exposure to the weather or by extremes of heat and cold. A timber frame, on the contrary, is liable to decay, which is hastened by exposure to the weather, and it is unfavorably affected by heat. More or less shrinkage of the timber always occurs, thereby relaxing the engagement of the several parts and disturbing the relations of the bearings which receive the strains caused by the load. The result of these changes in a timber frame is to permit more or less working of the parts one upon the other. This tends to augment the trouble from which it arises, and as a result the safety of the crane is lessened and its durability continually impaired.

So also in the bridges of traveling cranes. If the span be great, construction in timber involves much splicing, and this in turn necessitates unnecessary material in many places. The trussing and bolting requires a considerable amount of iron work, and usually necessitates a deeper girder than is required in iron, thus lessening the available head-room beneath the crane. It is believed that an accurate comparison of the relative costs of crane frames or girders built in wood and in iron, if proportioned with an equal factor of safety throughout, would show little if any economy of first cost in favor of wood.

The availability of iron for structures of this kind has been greatly increased by the ability of the mills to produce extreme lengths when required. No difficulty is now experienced in this country in obtaining the heaviest channel and I-beams in lengths of 50 feet or more, and the largest angle irons are also obtainable in single lengths of 80 or 90 feet. It thus becomes possible to form each of the principal members of cranes of a single continuous iron, the advantages of which are too obvious to need description.

It will be conceded that iron frames and girders are much to be preferred for every reason, with the single exception of possible

economy of first cost. Taking into account, however, all of the conditions and considerations above mentioned, it is believed that the difference in first cost is so slight—in many cases not appreciable—that the frames and girders of cranes of all, except perhaps the smaller kinds, should now be built entirely of iron.

In conclusion, it may be hoped that the foregoing analysis will conduce to a clearer understanding of cranes, both as regards their various forms or types, and the more important details of their construction. The tendency of the day in all directions is toward the specializing of products; that is, the concentration of the abilities and resources of individual establishments upon the development of certain distinct or special products. Consumers are the ones most benefited by this condition of things, since it enables them to procure products of higher quality and ultimately at a lessened cost. Where such specialists exist, the best result is usually attained by submitting to them a clear statement of the work to be done and of the surrounding conditions, and by accepting the advice thus obtained as to the type or form of machine best adapted to meet the special requirements of the case.

PART II.

PART II.

INTRODUCTION.

The contents of this Part comprise a full description of each of the more important details entering into the construction of the Weston Cranes, together with reproductions of many of the working drawings of the same.

In these days of keen competition it is not usual to make such an unreserved exhibit of the details which form the foundation of a successful business. If such information is published, it cannot be expected that interested competitors will not avail of it to further their own interests so far as they conveniently or legally may. It has been the policy, however, of the builders of the Cranes herein described to carefully and thoroughly protect their inventions and improvements by patent, and they are thus enabled to publish the results of their work with knowledge that its benefits are legally secured to them, and with confidence that their legal rights will be cheerfully respected without resort on their part to litigation for their enforcement. For further information on this point those interested are referred to the last page of Part II.

In describing the several details of crane construction, the author's effort has been to illustrate the important principles of action which they embody, rather than to describe the precise forms and constructions actually used. The latter necessarily vary somewhat in each type of crane in which any particular device is employed. The principle and mode of action of the various devices will, it is hoped, be made clear to the reader in the following pages, and the experience and facilities of the builders are a guaranty that the various adaptations are in each case properly made.

CRANE DETAILS.

Certain elements are found to be common to numerous types of cranes, and it will conduce to clearness and brevity of statement in Part III, which is devoted to descriptions of complete cranes, to describe these elementary parts and devices separately, in advance, rather than under the head of each kind of crane in which they occur. The following details employed in the Weston Cranes will therefore be thus described, viz. :

Chains ;
Chain Wheels ;
Spur Gearing ;
Worm Gearing ;
Frictional Safety Ratchet ;
Clutches ;
Bridge Squaring Device ;
Bridge Moving Device ;
Bridge and Trolley Moving Device ;
Trolley Traveling Mechanism ;
Gearing of Jib Cranes ;
Gearing of Traveling Cranes ;
Bridge Trucks ;
Frames and Girders ;
Bridges and Trestles ;
Power Transmission ;
Take-ups ;
Hooks ;
Blocks and Bushings ;
Foundations.

CHAINS.

The Chain Wheel system having been adopted by reason of the advantages it affords, as explained in Part I, the procurement of a true pitch chain becomes a necessity.

The same necessity exists in the Weston Differential Pulley Blocks, and the present makers of the latter, upon undertaking their manufacture in 1875, were compelled to devise and adopt a process of chain making which would insure the production of a chain of perfectly uniform pitch. To insure this result, a shop for chain making was erected and equipped with the best appliances, and the necessary skilled labor procured. Chain making is one of the few remaining manual trades in which modern machinery has not to a greater or less extent displaced the skill of the individual workman. Many attempts have been made to produce chains by machinery, and although some success has been attained, no machine-made chain has yet been produced having sufficient reliability and uniformity of quality to adapt it to use in cranes. The all-important operation in chain making is the process of welding the links, and in this the personal element seems indispensable to a perfect result, no machine, however perfect, taking the place of the skill and intelligence of the workman.

As used in the Weston Cranes, the pitch chains of the smaller sizes are made entirely of Norway iron, while for the larger sizes either Norway iron or American iron of high elasticity and ductility, is used. Each link is forged and welded with great care, and much more time and labor is expended on this part of the work than is the case with common chain. All of this pitch chain is made under a patented process, which consists in forging the chain slightly under pitch, after which it is first cleaned and brightened by "rattling," and then stretched in a special machine to the final gauge or pitch. The first process causes the several links to come into more perfect contact or bearing by removing the scale and other slight asperities from their surfaces. The

second process assists in bringing their adjacent surfaces into closer contact, tends to straighten the sides of the links, and gives the iron a slight initial set by straining it to a degree somewhat greater than that which will be caused by the load which it is intended to carry. The final step in the process is a careful and rigid inspection of each link of the chain and the removal of any which are at all imperfect. As a result of this treatment, a chain is obtained which is accurately uniform in pitch, and which, when used within the intended limit of load, will not stretch or alter its pitch. It is believed that the chain thus produced is more perfect and reliable than any made heretofore or elsewhere.

In determining the diameter of iron for the several sizes of chain, those sizes have been adopted which will limit the stress upon the links of the chain to a maximum of from 9,000 to 10,000 pounds per square inch of cross-section when carrying the full load. As the pitch chain was designed primarily for use in the Weston Differential Pulley Blocks, in which the load is always carried upon two parts of chain, the nominal capacity of the several sizes indicates in each case the maximum load intended to be carried upon *two parts* of the chain. A single part is, of course, capable of carrying a load of one-half the amount given in the table.

The following table gives the dimensions of the several sizes of the pitch chain above described.

Nominal capacity in Tons*.......	$\frac{1}{8}$	$\frac{1}{2}$	1	$1\frac{1}{2}$	2	3	4	5	6	8	10
Diameter of Iron in inches........	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{9}{32}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{13}{16}$

* The upper line indicates the load which can be *safely* carried on *two parts* of the chain, *i.e.*, as used in a one-sheave tackle block. Each part of the chain thus carries *one-half of the total load.* If the load is to be carried by a single chain, select a chain of a nominal capacity of twice the intended load.

CHAIN WHEELS.

Having provided a perfect pitch chain, the next essential is a chain wheel to drive it. This wheel must have pockets for the links of the chain to engage with, the pitch of which, or their circumferential distance from center to center, must coincide accurately with the pitch of the chain. The shapes of the several portions of these pockets are also matters of great importance and nicety. The bottom of each is tangential to the radius, thus giving a flat bearing for each link; the center is grooved to clear the links which present themselves on edge; and the teeth or shoulders between the pockets, by which the work of driving is done, are made as thick as possible, to resist the severe strains that come upon them, and yet are so curved on their two faces that the links, when entering, shall do so without strain or jar, and shall pass off again without clinging.

The exact shape of these teeth has been determined, partly by careful plotting, and partly by experiment, the experience acquired in the manufacture of the Weston Pulley Block, in which similar chain wheels are used, having greatly assisted in the determination.

The best material for the chain wheel has been found, by experience, to be soft cast iron, as this causes the least wear upon the chain, and as it is of course best to have the wear come upon the wheel (which is easily and cheaply replaced) than upon the chain. In all of the several types of cranes hereinafter described the chain wheels are made and inserted so as to be easily replaced. This, however, does not require to be frequently done, as the wheels will usually endure five or six years of constant use before wearing out.

To further insure the proper engagement of the chain wheel and chain, a chain guide is provided as shown in Fig. 1.

The functions of this chain guide are:—

(1)—To cause the chain to enter properly into engagement with the wheel;

(2)—To hold it in engagement with several of the pockets of the wheel, so that the strain upon the chain is distributed over these several pockets, and "stripping" of the wheel prevented; and

(3)—To permit the lower half of the wheel to be used for engagement with the chain and yet cause the slack side of the chain to follow the wheel up to the horizontal center line again.

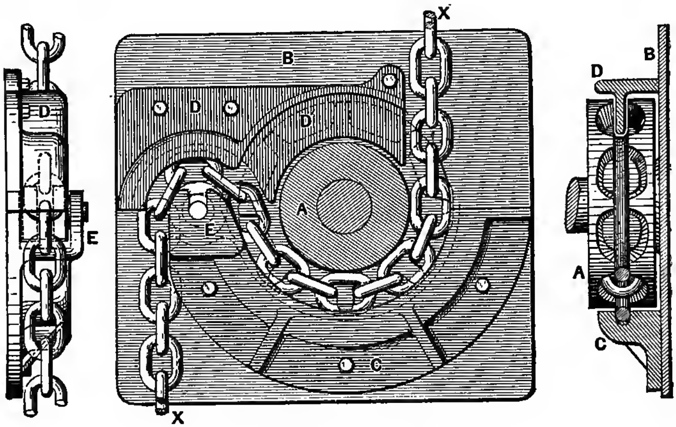


FIG. 1.—Chain Wheel, Guide and Stripper.

The construction by which these results are obtained is clearly illustrated in the cut, in which A represents a pocketed chain wheel mounted upon the plate or frame B. C is the "chain guide," enveloping the lower half of the chain wheel A, and bolted securely to the plate B. The inner curved surface of the chain guide is grooved, and is of such shape as to leave a space between it and the periphery of the chain wheel merely sufficient to admit the chain. The latter is thus compelled to enter properly, and is held securely in engagement with the pocketed chain wheel throughout the arc of contact. At E the chain guide carries a small roller, over which the slack chain passes downward into a suitable box or receptacle.

To insure the proper separation of the chain from the chain

wheel at the point of disengagement there is provided a "chain stripper." This piece, marked D in the cut, is also bolted to the plate B, and is provided with a projecting tongue or rib D′, the point of which lies deep in the center groove of the wheel, and thus strips or separates the chain from the wheel as it reaches the proper point, and prevents any clinging of the chain to the wheel. A prolongation of the "stripper" D covers the guide sheave at E and insures the proper passing downward of the chain.

The construction of the chain wheel and its adjuncts, which is above illustrated and described, constitutes a perfect device for hauling in and paying out chain, whether fully loaded or empty, and is moreover easier upon the chain, and more conducive to its endurance, than any ordinary form of winding barrel or drum. With slight modifications, to adapt it to the varying conditions, this construction is embodied in all of the various types of the Weston Cranes.

SPUR GEARING.

The proper action of many of the mechanisms employed in crane construction depends largely upon the character of the spur wheels used in effecting the necessary changes of speed and motion.

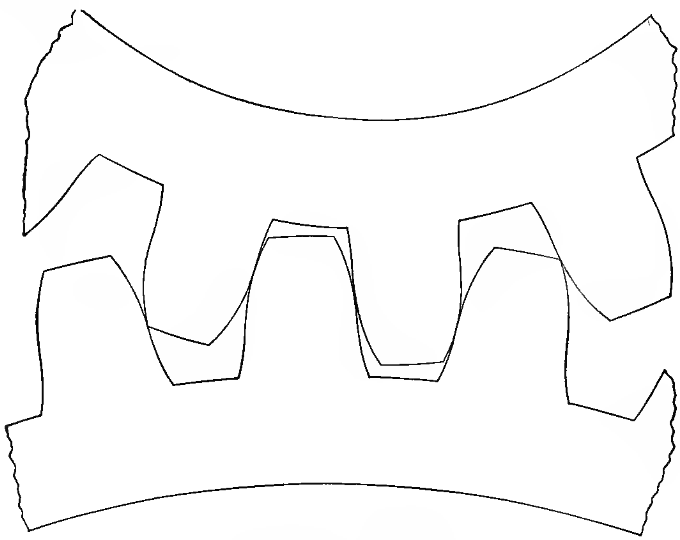


Fig. 2.—Teeth of Spur Wheels.

In all of the Weston Cranes which are operated by power, cut gears are used throughout. The rims of these wheels are cast solid and turned, after which the teeth are formed in a gear-cutting engine by means of suitable mills or cutters. The character of the work obtained in this way depends chiefly upon the shape or contour of the cutters by which the teeth are formed. The Pratt & Whitney Co., of Hartford, Conn., have given this subject the most exhaustive consideration, and have at great expense developed a system of producing cutters for gears which

are believed to be more perfect than any heretofore made. These cutters are used exclusively in the production of cut gears for the Weston Cranes.

The spur gears for cranes of the smaller sizes, and for operation by hand, are usually cast, not cut. These castings, however, are made from metal patterns, in forming the teeth of which latter the same kind of cutters are used; so that the cast gearing is relatively as good, in the essential matter of the contour of teeth, as is the cut gearing above referred to.

The general appearance of this gearing, and the shape of the teeth, is illustrated by Fig. 2.

WORM GEARING.

For the reasons stated under the head of "Hoisting Gear," in Part I, many advantages accrue from the use of worm gearing in the construction of hoisting machinery. Among these may be mentioned its compactness as compared with spur gearing, the ability to operate shafts at right angles to each other without resort to bevel gears, and great facility in the application of automatic brakes where necessary. In well proportioned worm gearing with cut teeth, friction cannot be relied upon to hold a suspended load from running down, but a very moderate brake resistance applied to the worm shaft will accomplish this result. If a load suspended through a train of spur gearing be allowed to run down, it will do so at an accelerating velocity approximating to that of a falling body. With worm gearing, however, very little acceleration takes place after a certain speed has been attained, and gearing of this kind thus becomes a safety device which prevents undue acceleration of the load even when running free, and is a most valuable means of preventing accidents, both to the mechanism and to those operating it.

The subject of worm gearing was very carefully investigated by the late Mr. Robert Briggs, C. E., and the following description of the correct method of construction, condensed from a paper by him,* fully describes the system employed in the worm-gearing used in the Weston Cranes.

There is a current opinion among machinists in general that worm gearing offers so disastrous a frictional resistance in wear, that its use, except for purposes where little power is to be transmitted, and where certain slow movements are to be effected, is not permissible in good mechanism. This view is supported by most of the text-books, which invariably represent the laying out

***Worm Gearing*, by Robert Briggs, C. E.; *Mechanics*, Vol. 1, No. 12, March 25, 1882, New York. See also Unwin's "Elements of Machine Design," Fourth Edition, London, 1882. page 499, *et seq.*

of the teeth by considering the worm as a rack with inclined teeth where the pitch-lines of the worm and wheel are taken on a plane passing through the axis of the worm.

Now, the fact is that the use of worm gearing for hoists, cranes, boring-bars, lathes, etc., has been growing in favor, and it is found that neither excessive loss of power, nor excessive wear of gearing ensues. In regard to friction, it is established that for the ordinary ratio of wheel to worm, say, not to exceed 60 or 80 to 1, well fitted worm gear will transmit motion backward through the worm, exhibiting a lower co-efficient of friction than is found in any other description of running machinery.

In order to reach this result the following method of laying out a worm gear and worm is employed. Assume the teeth on the worm to be 0.65 of the pitch radially, of which 0.60 P is to be the line of contact with the teeth of the wheel (on the radius and also on the plane through the middle of the teeth), and that 0.05 P be for clearances between the roots and points of worm and wheel teeth. Let the teeth of the wheel follow the circle of the worm throughout the arc, which ought not to exceed 60°. Let R = outside radius of worm; Rp = radius of pitch of worm; F = face of wheel at root of teeth; and P = pitch of teeth; then

$$Rp = \tfrac{1}{2} \{ R + (R - 0.6\,P) \operatorname{Cos} a \}$$

$$F = 2\,(R + 0.05\,P) \operatorname{Sin} a.$$

To simplify the process of laying out worm-wheels it has been usual to make the outside radius of the worm R = 2 P, and the angle a = 60°, when

$$Rp = 1.606\,P, \text{ and } F = 2.05\,P.$$

The effect of this method of setting out pitch-lines for the teeth of screw gearing is to bring the bearing, or working lines of contact, for both orders of teeth more nearly on the true pitch-line, and not to throw much effort or work on the points of the teeth of the worm wheel outside of the true pitch-line.

The following illustration represents a worm wheel and worm constructed in accordance with the above system and of the proportions employed in the Weston Cranes.

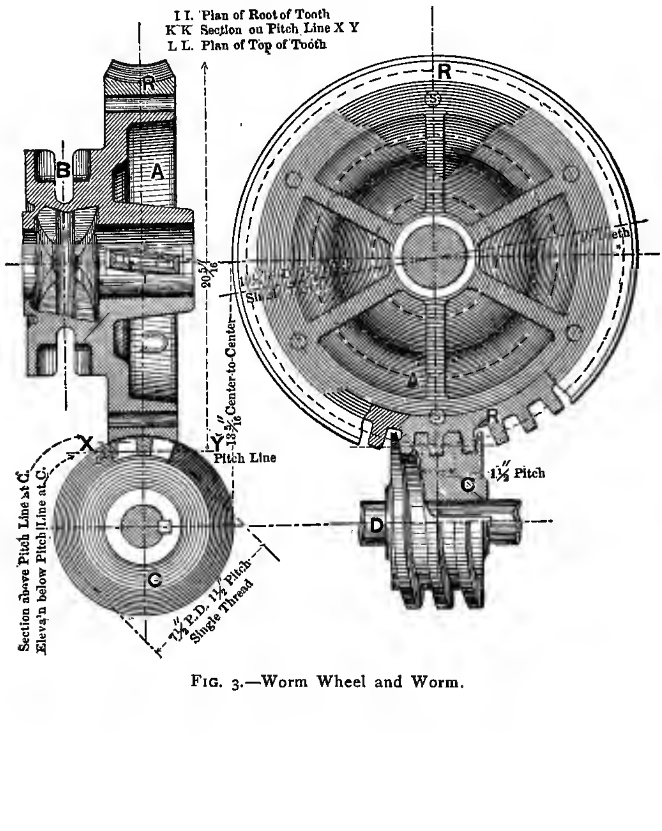


FIG. 3.—Worm Wheel and Worm.

FRICTIONAL SAFETY RATCHET.

The ordinary ratchet-wheel is a disc with teeth or indentations on its periphery, and in practice it is employed in combination with a pawl or dog arranged to engage with its teeth in such manner that the ratchet-wheel, being attached to a rotating shaft, is entirely free to revolve in one direction, but, by the action of the pawl, is prevented from rotation in the contrary direction. Thus arranged it is usually attached to the primary shaft of a winch, or other hoisting gear, so that, while it opposes no resistance to rotation of the shaft in the direction necessary for hoisting, it effectively prevents motion in the contrary direction. When it is desired to lower the load the pawl is thrown out of engagement with the ratchet-wheel, and the load then lowered by turning the cranks backward, or by letting go of the cranks and controlling the descent of the load by a brake applied to the shaft.

Both of these arrangements are dangerous, and are productive of serious accidents. Where lowering is effected by turning the cranks backward with the pressure due to the load upon them, it frequently happens that a heavy load overcomes the operator, in which case the cranks begin to revolve with great violence and often strike the operator before he can escape from their reach. Where a brake is used there is less danger, but even then the safe descent of the load is contingent upon the skill with which the brake is used, and any lack of skill or watchfulness will result in a rapid descent of the load. In this case, if the motion is not checked the load may descend so rapidly as to cause damage, while if its motion be suddenly arrested by the brake, the shock and strain thereby induced are apt to damage the crane.

A Friction Ratchet is one in which the action of friction is substituted for the teeth and pawl of the common ratchet, so that the retaining action of the ratchet will take place instantly and in all positions. A Safety Ratchet may be defined as one in which lowering of the load is effected by reversing the motion of the

shaft to which the ratchet is attached without any disengagement of the pawl or its substitute, the construction being such that so long as this backward motion is continued the load will descend, but that when it is discontinued the load will automatically come to rest, from which it follows that with a Safety Ratchet the cranks or handles of a hoisting machine may be "let go" at any time, either in hoisting or in lowering, the ratchet thereupon automatically holding the load suspended and preventing "running down" or descent of the load.

The great desirability of so important a result has long been conceded, but most of the devices heretofore invented for its accomplishment have been so complicated, or so uncertain in action, as to find little favor. These objections, however, have been fully overcome in the devices employed in the Weston Cranes and other hoists, some of which are described below.

No one form of Safety Ratchet is applicable, without modification, to all of the varying requirements of hoists and cranes. One of the simplest forms is that employed in the Weston Double-Lift hoist, (see Part IV) the general construction of which is as follows:

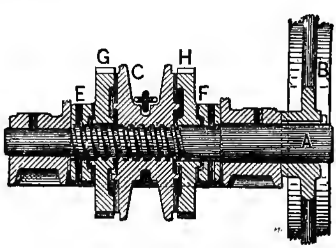


Fig. 4.—"Double-Lift" Safety Ratchet.

Fig. 4. is a sectional view of this machine in which A is the main shaft or axle, and B a rope wheel, attached to one end of the shaft, by means of which motion is communicated to the latter through an endless rope or chain passing over the wheel and extending downward to the operating floor. C is a pocketed chain wheel over which passes the hoisting chain, each end of which latter is provided with a hook for attaching the load. The

center of this wheel is tapped with a screw-thread coinciding with a screw cut upon the central portion of the shaft A. G and H are two ratchet-wheels with their teeth inclined in opposite directions. Each of these is provided with a suitable pawl pivoted to the frame of the machine, the effect of which is to permit each wheel to revolve in one direction, but to prevent its rotation in the opposite direction. One of them is thus free to revolve to the right and the other to the left. E and F are collars fitting to the shaft and pinned fast to it so that they rotate with it. Beyond these collars on each side are journals in which the shaft A revolves and which are formed within the frame of the machine. The action of this machine is as follows: Supposing the load to be hung on that side of the chain which is nearest the eye in Fig. 4, its effect is to cause the chain wheel C to rotate forward, thus screwing it upon the shaft A in the direction of the ratchet-wheel H. As soon as it is moved into contact with the latter the frictional adherence between the two tends to rotate the ratchet-wheel H with the chain wheel C. This is prevented, however, by the pawl engaging with the wheel H, so that further descent of the load is arrested. Under these conditions the pull of the load tends to screw the chain wheel C further to the right, and this being prevented by its pressure against the ratchet-wheel H, which in turn is supported by the collar F pinned to the shaft, the further tendency of the load is to rotate all of the parts just referred to, this action being prevented by the pawl engaging with the ratchet-wheel H. If now the hand rope passing over the rope wheel B be pulled in the direction necessary to cause hoisting of the load, all of the parts above enumerated will remain locked into engagement by the pull of the load and will rotate together, the load thus rising in the usual manner. If at any time the strain on the hand-rope be relaxed the pull of the load will rotate the parts backward until the pawl engages with the next tooth upon the ratchet-wheel H, when all will come to rest and remain suspended as before.

If, however, the rope-wheel B be rotated in the opposite direction, in order to lower the load, the following action will occur. The first movement of the wheel B will cause the shaft A to

rotate in a direction which tends to unscrew the chain-wheel C from its engagement with the ratchet H, by causing it to move towards the left. As soon as this unscrewing has progressed to a point which releases the frictional engagement of the wheel C with the ratchet H, the former will commence to revolve under the influence of the load, but in so doing will overtake the shaft A and again screw itself up into frictional engagement with the ratchet H. The continued rotation of the latter, however, will again release the chain wheel C, which will again move instantly forward and overtake the shaft. In point of fact, these successive releasings and engagements are imaginary rather than actual, the real action consisting of forward motion of the screw upon the shaft followed by a corresponding movement of the chain wheel under the influence of the load, the forward motion of the latter continuing so long as the shaft is rotated by the shaft B, but ceasing whenever the motion of the latter is discontinued. The action of lowering which thus takes place is perfectly smooth and continuous, and is effected with but slight effort upon the rope wheel B. Upon its discontinuance at any time the pull of the load instantly locks the chain wheel C against the ratchet H, which in turn is held by its pawl, and the parts immediately come to rest and the load remains suspended.

Should the load be hung upon the other or opposite hook its effect will be to screw the rope wheel C against the ratchet-wheel G, the teeth of which are inclined in a direction opposite to those of the wheel H. In this case the same action as above described takes place, but in a contrary direction, the ratchet-wheel G holding the load suspended and the wheel H moving idly with the shaft.

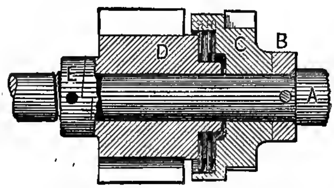


Fig. 5.—Spur Pinion with Safety Ratchet.

Although somewhat complicated to describe, the action of this machine is exceedingly simple and is absolutely reliable under all conditions, as is well known to the many users of the Weston Double Lifts, in which it is employed.

Another form of safety frictional ratchet is shown in Fig. 5, in which A is the primary shaft of a hoist and D a spur pinion carried by said shaft and gearing into a proper spur wheel upon the second shaft. C is a ratchet-wheel having teeth on its periphery which engage with an ordinary pawl pivoted to the frame of the machine, thereby preventing its rotation except in one direction. E is a collar screwed and pinned fast to the shaft A so that it rotates with it, and B a similar collar at the opposite side. The collar A has a helix formed upon its side which adjoins the pinion D, and the hub of the latter has a corresponding helix, so that the two when in coincidence appear as shown in the cut. The pinion D and ratchet C are loose upon the shaft A. Assuming that to effect hoisting the shaft A must be revolved so that its upper surface, as seen in Fig. 5, moves toward the eye, in which case the resistance due to the load tends to retard or hold back the pinion D, the shoulder upon the collar E, as the latter revolves with the shaft A, will move away from the corresponding shoulder upon the hub of the pinion D, the effect of which is to cause the two helices to mount upon each other, thereby pushing the pinion D to the right upon the shaft and forcing it into frictional engagement with the ratchet-wheel C. The latter being supported by the fixed collar B, the several parts are thus locked together and will thereupon rotate simultaneously, the teeth of the ratchet C being inclined so as to permit of motion in this direction. If at any time the rotation of the shaft A be discontinued the pressure due to the load will tend to rotate the pinion B backwards, but all of the parts being locked together, as already explained, backward motion is prevented by the action of the ratchet-wheel C and the load will thus remain suspended.

When it is desired to effect lowering, the shaft A must be positively rotated backwards, the effect of which will be to relax the longitudinal engagement of the several parts by the rotation of the collar E, the helix upon which will thus move forward into coincidence with the corresponding helix on the hub of the pinion B. As soon as this movement of the collar E is sufficient to relax the longitudinal pressure, the pull of the load will cause the

pinion ~~B~~ D to follow the rotation of the shaft and to overtake the collar E, thereby again applying the longitudinal pressure unless the continued backward motion of the shaft again releases it. This alternate releasing and re-engagement will then continue so long as the shaft is revolved backward, in a manner precisely similar to that occurring in the Double-Lift mechanism shown by Fig. 4. During this reverse motion of lowering, the ratchet-wheel C remains stationary by reason of the engagement of the pawl with its teeth. Should the pinion D from any cause fail to follow the shaft in its backward motion the shoulder upon the collar E will immediately overtake the corresponding shoulder on the hub of the pinion, and the latter will thereupon be positively driven backward. If desirable to increase the frictional adherence between the pinion D and the ratchet C, a series of Weston friction discs may be interposed between their abutting surfaces, as shown in Fig. 5.

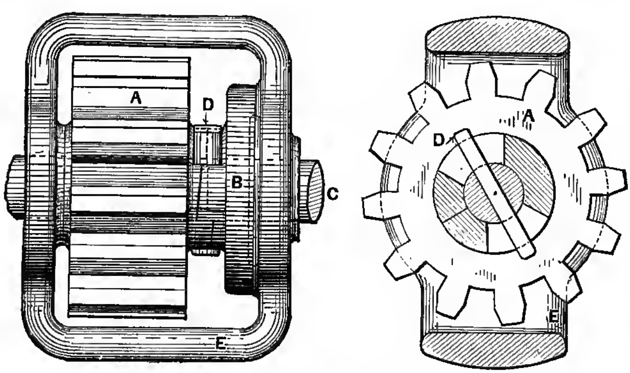


FIG. 6.—Safety Spur Pinion.

In each of the preceding examples an ordinary ratchet-wheel and pawl is employed to prevent backward motion of the shaft under the influence of the load. Fig. 6 represents another form in which the ratchet also is frictional and no toothed ratchet-wheel is required. In this case the pinion A and the frictional ratchet or collar B are both loose upon their shaft C. The adjacent hubs of these two parts have formed upon them a helix

similar to that shown in Fig. 5, so that when turned in contrary directions the two helical surfaces mount upon each other and produce a longitudinal pressure which locks the several parts into frictional engagement with the sides of the housing E, and so prevents the backward rotation of the pinion under the pressure of the load. In this case the parts occupy the relative positions shown in the sectional view, the cross-pin which is attached to the shaft standing midway between the two shoulders on the opposite helices. If the shaft be rotated in a direction to cause hoisting, the cross-key D moves forward until it picks up both the pinion A and collar B by pressing against the slotted openings in their hubs, and thus presses them into a position where the longitudinal pressure of the helices is relaxed and the parts rotate freely with the shaft. If this action be discontinued while the load is suspended the pinion A will rotate backward through a small arc carrying with it the key D and shaft C, while the collar B remains stationary, and in this way the helical hubs restore the end pressure and the parts are again locked fast. If the shaft then be rotated backward, the key D will first pick up the collar B by pressing against the slot in its hub and move it forward into coincidence with the corresponding slot in the hub of the wheel A, when, the end pressure being relaxed, the parts will again rotate freely so long as the shaft is turned backward, but upon the discontinuance of this motion the pressure of the load will again move the wheel A backward until the end pressure is restored. The exterior frictional face of the collar B is of larger diameter than that which abuts against the hub of the pinion A, and the frictional resistance against the frame, thus acting at a greater radius, is sufficient to resist the strain of the load and hold the pinion stationary.

Fig. 7 represents the same arrangement as that just previously described in its application to a worm. The force necessary to prevent backward motion of a worm under the pressure due to the load is usually quite small, and this device thus becomes particulary applicable, owing to its simplicity and compactness.

From the foregoing the general character of the frictional safety ratchets employed in the Weston Cranes will be understood. Although difficult to describe in this manner they are all

exceedingly simple, both in construction and action, and have now been so thoroughly tested under the most varying conditions of service as to make their employment no longer experimental or of doubtful expediency. Their application to the varying require-

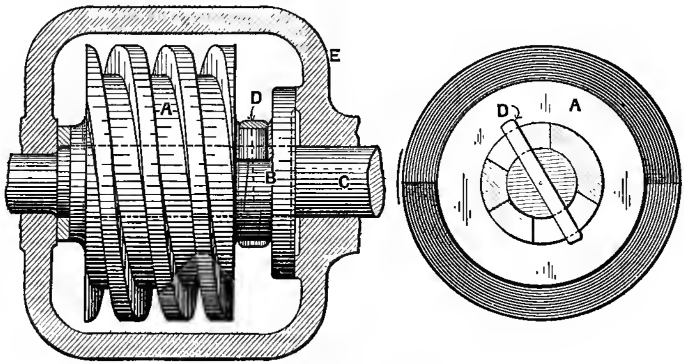


FIG. 7.—Safety Worm-Pinion.

ments of crane construction requires numerous modifications which are not here shown, but the essential principles of all are substantially identical with those above described.

CLUTCHES.

In all cranes operated by power one or more clutches are essential to the convenient operation of the mechanism. Experience has demonstrated that the best and most reliable clutch for this purpose is that invented and patented by Mr. Thomas A. Weston, M. E., and first fully described in a paper read by him before the British Institution of Mechanical Engineers, from which we condense the following description, and extract the cuts by which it is illustrated.

The essential basis of the Weston Clutch or coupling consists of two series of friction discs arranged alternately with each other upon a common axis, one series being carried by one shaft, and the other series connected to the other shaft or wheel which is required to be coupled with the first shaft. The great advantage arising from this alternate arrangement of the discs is that the frictional effect of any pressure applied to couple them is repeated as many times as there are discs in the two series, that is, the number of all the discs is a constant multiplier for the friction produced between a single pair of the rubbing surfaces by any given pressure.

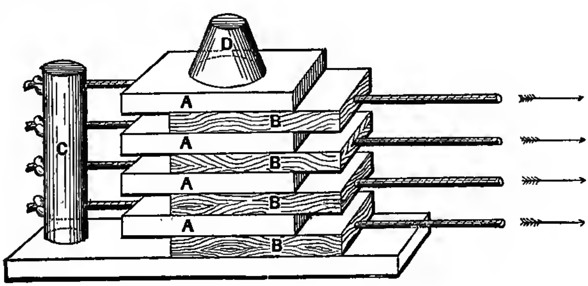


Fig. 8.—Model of Alternate Friction Plates.

This principle of the multiplication of frictional surfaces is illustrated by the diagram, Fig. 8, where, instead of two series of discs, there are shown two series of short, flat plates, arranged

like the discs, alternately with each other. The one series AA are severally tied to the fixed pillar C, and each one of the other series BB has its sides in frictional contact with two of the first series. The applied pressure for frictionally coupling the two series is furnished by the weight D. Upon withdrawing any one of the series B in the direction shown by the arrow, a certain degree of resistance will occur, in consequence of the friction upon its two sides due to the pressure of the weight D. Upon withdrawing two of the series B together, twice as much resistance occurs; and if the whole series BB are simultaneously withdrawn, the resistance is further increased in proportion to the whole number in that series. Hence, as the number of the plates or discs may be indefinitely increased, an indefinite increase or extension of frictional area may be obtained without any reduction of the pressure per square inch upon the rubbing surfaces; in consequence of which the remarkable result is obtained of an indefinite increase in the total amount of friction with the same load.

In Fig. 9, is represented a form of experimental friction brake, or coupling, composed of two series of circular friction discs AA and BB, the relative motion of the rubbing surfaces being circular instead of in a straight line, as in Fig. 8. The shaft discs A are made an easy fit upon the square shaft C, so that they may slide to or from each other upon the shaft into more or less intimate contact with the intermediate discs B; and the latter, when no coupling pressure is applied, are capable of turning freely upon the circular bosses of the shaft discs A. The coupling pressure is applied or withdrawn by means of the crank-lever D, the short forked arm of the lever compressing the discs longitudinally upon the shaft against the fixed pin E. So long as no compression is applied, the shaft C can rotate freely, carrying with it the discs A, which do not then transmit any driving force to the discs B; but upon compressing the discs into frictional contact with each other, the rotary motion of the shaft will be transmitted by the discs A to the intermediate discs B. The rotation of the shaft being maintained, and the discs B being held from turning by a cord F wound round the circumference of each,

the tension upon each cord measures the friction between each two pairs of the circular rubbing surfaces; and the strain upon

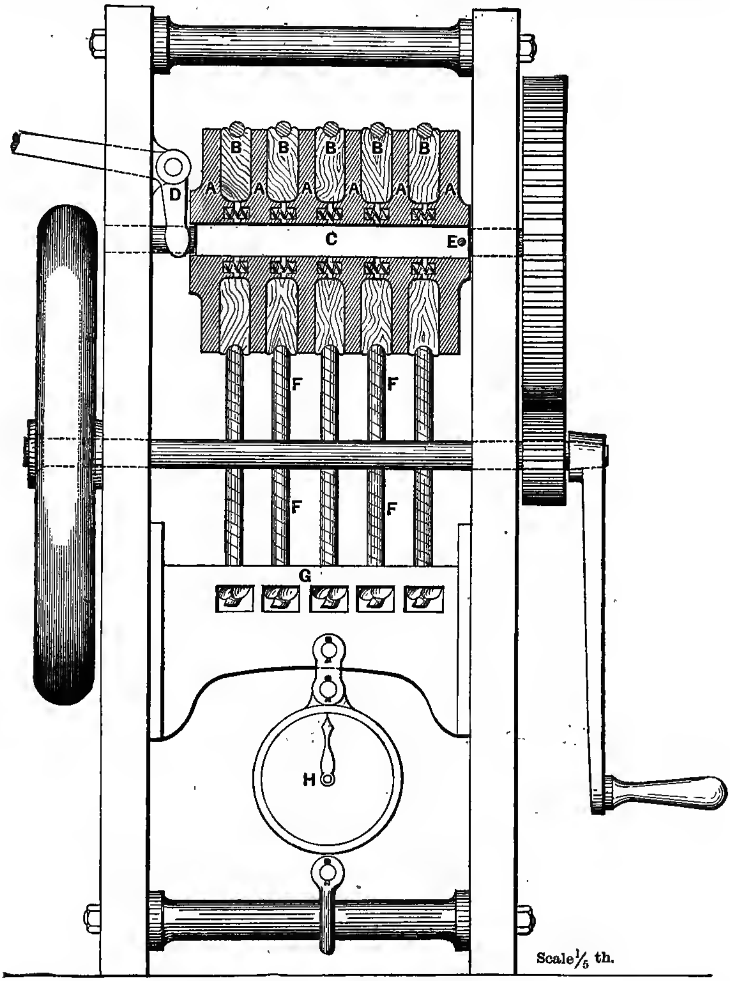


FIG. 9.—Experimental Friction Brake.

all the cords taken together is the total force which the whole series of intermediate discs B is then absorbing by brake

action upon the shaft discs A. This strain is indicated by the spring balance H, upon which all the cords pull by the intervention of the cross-bar G. To illustrate the uniformity of action of the device, the coupling pressure at D may be applied gently and increased by imperceptible gradations to any required extent, and in like manner be gradually withdrawn again ; and the tangential force indicated by the spring balance H will simultaneously rise and fall with the same steady regularity. The coupling pressure may also be applied and withdrawn very suddenly, or even with a jerk, and proportionate extremes of force will then be indicated with the same abruptness by the spring balance H. This sensitiveness of the friction coupling is due to the parallelism

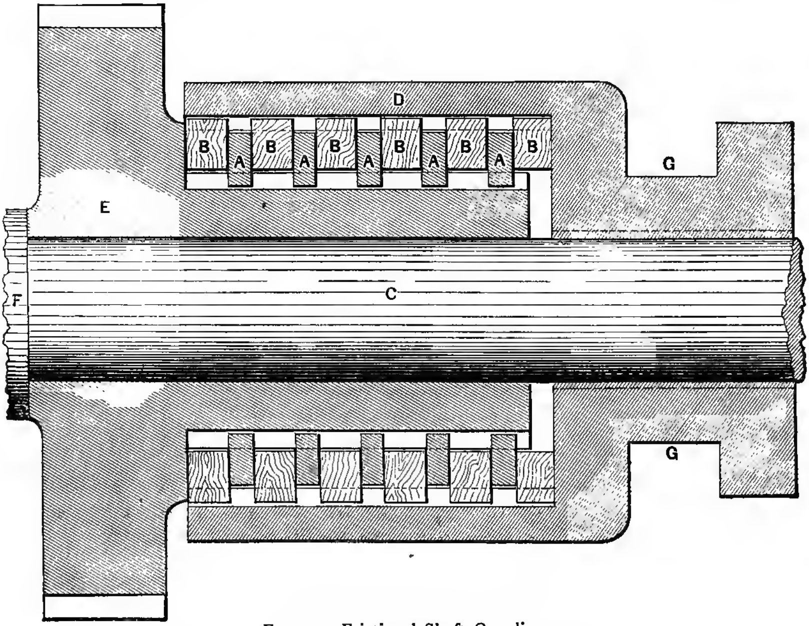


Fig. 10.—Frictional Shaft Coupling.

of its rubbing surfaces, since the frictional action between parallel plain surfaces necessarily fluctuates in true and instant correspondence with every variation of the applied pressure.

In Fig. 10 is shown, in longitudinal section, a simple form of shaft coupling; and in Figs. 11 and 12, transverse sections showing the alternate iron and wood discs separately. The five iron discs A engage with solid keys on the long boss of the spur wheel E, within which the driving shaft C turns freely when no coupling pressure is applied to the discs. The drum D containing the six intermediate wood discs B, slides on feathers on the

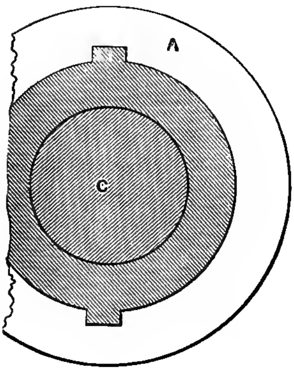


FIG. 11.

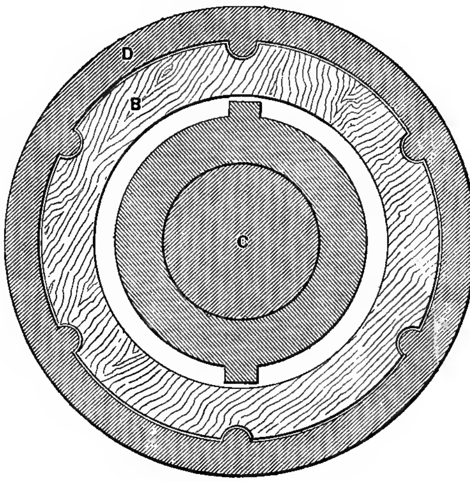


FIG. 12.

shaft C, and the groove G on the outer end of the drum receives the forked end of a lever by which the coupling pressure is applied, compressing the discs against the fixed collar F on the shaft, and thereby coupling the spur wheel E to the shaft C. . . . . The paper from which these extracts are quoted contains a number of other illustrations and descriptions indicating the wide range of applicability of the Weston Frictional Coupling, and demonstrating its convenience and efficiency under the most varied conditions.

The Weston Clutch, then, consists essentially of two series of thin discs, one series locked, by the central openings, to its

shaft, and the other series locked, by their peripheries, through the medium of a surrounding box or shell, to the other shaft, both series being free to slide longitudinally upon their shafts, and thus being capable of engagement by longitudinal pressure. The system admits of indefinite expansion as to its power, either by multiplying the number of discs in each series, which slightly increases the longitudinal space occupied; or by enlarging the diameter of the discs, and thus increasing the radius at which their frictional resistance acts, the result of which is to enlarge the diametral dimensions of the clutch.

The Weston Disc Clutch has already been tested by years of constant use under varied conditions and heavy duty. It has been found applicable not only to the transmission of small amounts of power through light shafting, but equally to the transmission of large amounts of power, and to the resistance of the severest strains, as, for example, in operating the mechanism of powerful dredging machines, and in driving the heaviest rolling mill machinery. For this latter purpose Weston Disc Clutches have been built with capacity to transmit the entire power of a 1000 horse-power steam engine used in driving a train of rolls for making rails, the purpose of the clutch being to reverse the motion of the train. In this case the discs were 9 feet in diameter and 1 inch thick, of wrought iron. These latter clutches have been some time in use and have operated in a perfect manner.

The Weston Clutch exceeds all others in compactness, as well as in its capacity for indefinite expansion, and has the additional merit of great simplicity and great durability. Experience has proven that for most purposes it is best to use iron or steel discs exclusively; and that these, properly made, will last for years without any apparent wear.

THE WESTON-CAPEN CLUTCH.

To adapt the Weston Disc Clutch to crane work it became essential to provide a means of conveniently applying the longitudinal pressure upon the discs without thereby inducing any collar friction. This is effected by the patented improvements of Mr. T. W. Capen described below, the objects of which are to produce end-pressure between two pieces, both attached to and revolving with an ordinary shaft, and to do this, whether the shaft be in motion or at rest, without causing any additional friction, either upon the journals or the collars.

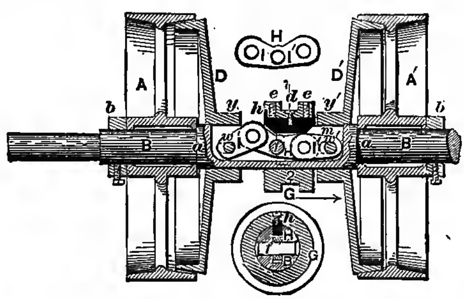


FIG. 13.—Friction Pullies with Capen Toggles.

Fig. 13, above, represents the Capen toggle device as applied to an ordinary friction clutch, in which the friction is obtained from a pair of inclined surfaces, at the periphery of the wheels, held in engagement by longitudinal pressure. The toggles are used to effect this pressure, and their action will be readily seen by reference to the cut. The lever H is contained within the slot *m* of the shaft, and is pivoted to the latter by a pin *f*. One arm of this lever is connected by a link I to a pin *w* which passes through the shaft and through the hub *y* of the clutch D. The other arm of the lever is similarly connected by a link I′ and a pin *w*′ to the clutch D′. The holes in the shaft through which the pins *w* and *w*′ pass, are elongated so that each clutch may

have a limited sliding movement on the shaft, without being able to turn independently on the same.

Sliding upon the shaft between the clutches is the sleeve or collar G, which is provided with a projection *h* (shaded black in the cut), fitted into and moving freely within the slot *m* of the shaft. The central portion of this projection *h* is straight and parallel with the shaft, while at each end is an incline or bevel.

As shown in Fig. 13, the sleeve G has been moved in the direction of the arrow so far that one arm of the lever H has been depressed so that its center line coincides with the center line of the link I′, and the clutch D′ thus moved into rigid engagement with the frictional surface of the pulley A′; at the same time, the tilting of the other end of the lever H, acting through the link I, has caused the disc D to be removed from frictional contact with its pulley A. In this position the straight portion of the projection *h* bears on the link I′, and holds it in position, without requiring any effort or strain to keep the sleeve G in position. The latter may be moved by the ordinary forked shipping lever, but it will be seen that the action of the collar G holds the clutches in their relative positions independently of any aid from the mechanism for operating the sleeve, and thus avoids all end-thrust and collar friction upon the shaft, the coupling pressure being self-contained between the shaft and the rotating parts. Upon moving the sleeve G in a direction contrary to the arrow, the link I is depressed and the clutch D forced into engagement with its pulley A, while at the same time the link I is drawn up and back, thus positively disengaging the clutch D′ from its pulley. If the sleeve be adjusted to a position midway between the clutches, both of the latter will be free from contact with their respective pullies. The foregoing illustrates the simplest form of the toggle device. Its application to the Weston Disc Clutch is illustrated in Fig. 14.

Fig. 14 is a cross-section and end elevation of a Weston Disc Clutch with the end-thrust upon the discs effected by a simple forked lever of the ordinary type. The principal parts consist of the wheel or pulley A running loose upon the shaft B, to which it is to be connected by means of the clutch when desired, and

the follower C, the hub of which is bored to fit freely upon the shaft B so as to move longitudinally thereon. This hub is key-seated to fit the key or spline *c* upon the shaft B, so that while the follower is free to slide longitudinally upon the shaft, neither can revolve without carrying with it the other. Within the wheel A are the two series of discs XX and YY. These are most clearly seen in the end elevation, in the upper half of which is shown a portion of one of the discs X, the central opening of which fits closely upon the square hub *c'* of the follower C, while in the lower half is shown a portion of one of the discs Y, the central aperture of which is circular, and large enough to avoid

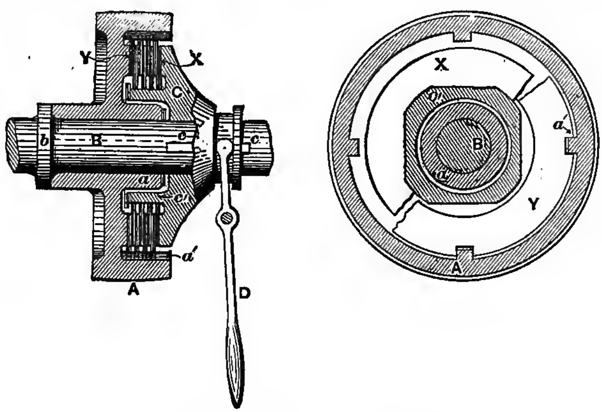


Fig. 14.—Simple Form of Weston Clutch.

contact with the square hub *c'*, while its periphery, being larger than that of the disc X, extends to the interior periphery of the rim of the wheel A, and is engaged with the latter by means of notches fitting over the several ribs *a'a'*. It follows, of course, that the discs XX must all rotate with the follower C, by reason of their engagement with its square hub *c'*, and that the discs YY must all rotate with the wheel A by reason of their engagement with it through the ribs *a'a'*. Each series of discs, however, is free to slide longitudinally, the one upon the hub *c'* and the other upon the ribs *a'a'*, so that, while the shaft B, being suitably driven,

may revolve at any desired speed, the wheel or pulley A need not revolve with it, but may remain at rest. Now, by pulling the hand lever so as to cause longitudinal pressure between the two series of discs, the follower C, which rotates with the shaft B, will be frictionally engaged with the wheel A, thus clutching the two together and causing the wheel to rotate with the shaft.

The fulcrum of the hand lever being upon some fixed support, the construction shown in Fig. 14 would necessarily involve considerable friction between the forked hand lever and the hub or collar of the follower C, the amount of this friction depending upon the longitudinal pressure required to develop sufficient adhesion between the disc surfaces to transmit the desired amount of power. The collar friction thus generated would consume a considerable proportion of the power transmitted, and would involve serious wear upon the parts. All trouble of this kind is obviated by the application of the Capen toggle device, in the manner illustrated below.

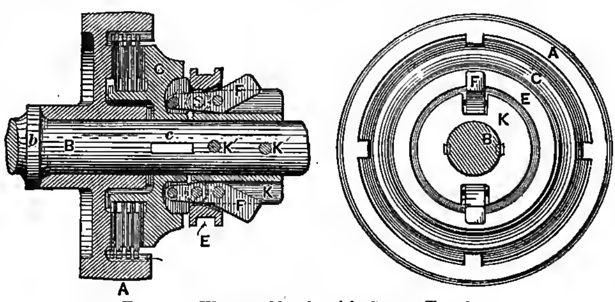


FIG. 15.—Weston Clutch with Capen Toggles.

Fig. 15 is a cross-section and end elevation of a Weston Disc Clutch with the Capen toggle device applied for producing the necessary end-thrust upon the discs. The several parts of the clutch are substantially the same as in Fig. 14, except that to the right of the follower C is the separate hub K secured to the shaft B by two pins *k'k'*. The hub K is grooved upon two of its opposite sides, and within these grooves are located the toggles FF. Sliding upon the hub K is the grooved ring or collar E, the

internal surface of which acts upon the toggles FF, while its external surface is grooved to permit of engagement with an ordinary forked lever, substantially as shown in Fig. 14. The construction and action of the toggles is shown to an enlarged scale in Figs. 16 and 17, in which L indicates the pin by which the toggle F is pivoted to the hub K, and N is the link which unites the toggle F to the follower C (Fig. 15). M is a roller, turning upon the pin which unites the link N to the toggle F, the purpose of this roller being to relieve the friction of the collar E when acting to press the toggle into the position shown in Fig. 16 to cause longitudinal pressure upon the discs. As shown in Fig. 17, the collar E is withdrawn to the position it occupies when the discs are relieved from pressure and the clutch is disengaged To effect clutching the collar E is moved to the left until it occupies the position shown in Fig. 16, in doing which it comes in contact with the roller M and depresses the left hand end of the toggle F, thus causing it to assume the position indicated in Fig. 16. At the first moment of contact between the collar E and the roller M there is a slight amount of resistance, but as soon as the collar E has passed over the roller M this disappears entirely, all of the parts shown in Figs. 16 and 17 then rotating simultaneously with the shaft, and the forked end of the clutch lever lying loosely within the groove of the collar E. The longitudinal pressure developed by the toggle when in the position shown in Fig. 16 is transmitted directly from the pin L (which is supported by the hub K, which in turn is pinned to the shaft B) through the link N to the follower C (see Fig. 15), whence it passes through the two series of discs to the wheel A, through the hub of which

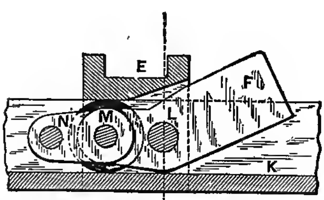


FIG. 16.

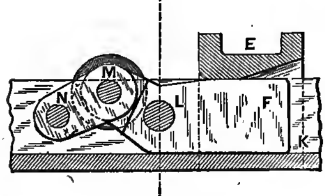


FIG. 17.

it is transmitted to the collar *b* on the shaft B. It is evident, therefore, that the longitudinal pressure employed for causing engagement between the two series of discs is borne directly by the shaft B, the collar *b* acting as one abutment and the pins *k'k'* as the other, the longitudinal pressure being expended between them, and all of the strained parts rotating together.

Both series of discs being of metal, it becomes necessary to make a close adjustment of the relative longitudinal positions of the wheel A and the follower C, so that when the clutch is engaged the proper pressure may be exerted upon the discs enclosed between them, and so that any wear of the parts may be conveniently taken up and the adjustment restored. To accomplish this the adjusting device shown in Figs. 18, 19 and 20 is employed.

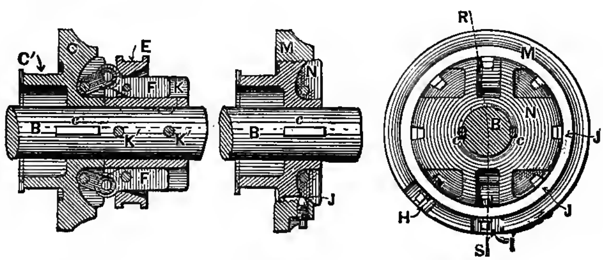


FIG. 18. FIG. 19. FIG. 20.

In Fig. 18 is represented the hub K, and connecting parts, precisely as shown in Fig. 15. Figs. 19 and 20 show the follower C with the adjusting device added. The follower C is somewhat reduced in diameter and upon its periphery a fine screw-thread is cut. Over this passes the adjusting ring M, the central opening of which is threaded to screw upon the exterior of the follower C. Thus arranged, the contact of the follower with the discs (see Fig. 15) is through the medium of the ring M, so that by screwing the latter forward or back upon the follower C the engagement of the latter with the discs may be varied to give the exact amount of pressure desired. The adjusting ring M is provided with two set-screws H and I (Fig. 20), and upon the periphery of the follower C are eight longitudinal grooves JJ

of beveled section, as shown in Figs. 19 and 20. The screws H and I are separated by a distance slightly less than the pitch of the grooves JJ, so that when the beveled point of the screw H bears against the right hand side of one groove, the beveled point of the screw I will bear against the opposite or left hand side of the adjacent groove. In this way a pinch, or locking action, is obtained which holds the several parts in rigid engagement and prevents all looseness or play. By backing out the screws H and I the adjusting ring M can be turned upon the screw-thread to the proper point and then rigidly secured again to the follower C by tightening the set-screws H and I.

The foregoing cuts and descriptions illustrate clearly the construction and action of the Weston-Capen Clutch as applied to the engagement of a spur wheel or pulley with a shaft, whether for the transmission of power from the shaft to the wheel or from the wheel to the shaft. By a slight modification of the external parts the clutch is equally adapted to the engagement of one shaft with another. In all of its various forms the Weston-Capen Clutch posseses entire freedom from collar friction, and the capability of adaptation to the widest range of uses. It is equally sensitive and reliable in its smallest and in its largest forms, whether in the counter-shaft of a lathe or upon the main driving shaft of a large engine. Its parts, being entirely of metal, are unaffected by atmospheric changes, either of temperature or moisture, and the provision for adjustment enables the pressure upon the discs caused by the action of the toggles to be regulated with the most perfect nicety, according to the varying requirements of the work to be done. The parts composing the clutch are few and simple, and the wear is chiefly upon the metal discs, which are easily and cheaply renewed when necessary. In economy of weight of revolving parts and of space occupied, and for absolute reliability under all conditions of use, experience has proved that this clutch excels all others, particularly in adaptability for use in the mechanism of cranes.

SQUARING DEVICE FOR MOVABLE CRANE BRIDGES.

For the reasons stated under the title of "Traverse Gear," in Part I, it is found that "a perfect system of bridge propulsion must hold the bridge always absolutely square with its tracks, and must propel the opposite ends of the bridge in the same direction, at the same time, and at the same speed." The device by which this important purpose is effected in the Weston Traveling Cranes is illustrated and described below.

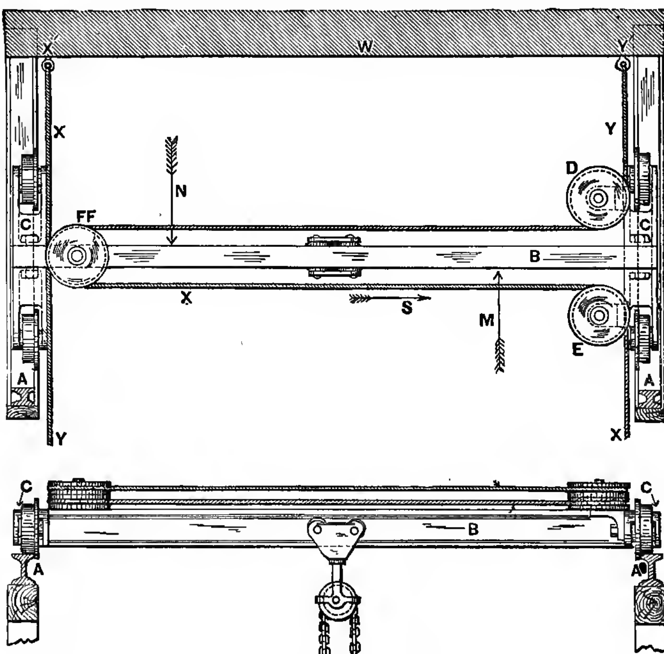


FIG. 21.—Device for Squaring Movable Bridges.

Fig. 21 represents a simple form of overhead crane consisting of a pair of longitudinal tracks AA, resting upon which is the

bridge B, provided at each end with a two-wheeled truck CC the wheels of which move upon the track and support the bridge. Attached to the bridge are four guide sheaves D, E, F, F, the two latter being upon a common axis, one above the other. At one end is shown the wall W of the building containing the crane and supporting the ends of the longitudinal tracks. Two wire ropes, indicated respectively by the letters X and Y, acting through the medium of the guide sheaves, constitute the squaring device for the bridge. The rope X is made fast to the end-wall W at the point X′, and leads thence around the upper guide sheave F, across the bridge, around the guide sheave E, and so to the opposite end of the longitudinal tracks, where it is made fast to another wall, or other suitable abutment, in the same manner as at the starting point X′. The other rope Y is attached in like manner to the wall W at the point Y′ and passes first around the guide sheave D, then across the bridge and around the lower sheave F, and so to the opposite end of the tracks, where it is made fast in the same manner as at the starting point Y′. Each of these two ropes, therefore, starts from a fixed point or abutment at one end of the tracks, and is made fast to a similar abutment at the other end, but between the two is carried by guide sheaves across the bridge, so that its two ends are at the diagonal corners of the space enclosed by the tracks, and the two ropes thus pass one another upon the bridge.

If, now, lateral pressure be applied to the bridge, tending to move it longitudinally in either direction, it is still free to move, the guide sheaves D, E, F, F rolling upon the fixed cords X and Y as the bridge moves along. If the propelling power be applied directly in the center of the bridge, and if the weight of the bridge and its load be divided equally between the two end-trucks, the bridge will move in parallelism with its tracks without any tendency to get out of square or to cramp, and no squaring device is needed. If, however, the propelling power be applied at some other point than at the center, as, for instanee, at the point indicated by the arrow M, the right hand end of the bridge will tend to move more easily and more rapidly than the opposite end; particularly if it should happen that the load carried by the bridge rested at

the time at or near the left hand end of the bridge. This increased resistance to traction at the left hand end of the bridge may be represented by the arrow N, acting in a direction contrary to the force at M, the combined result being a tendency to rotate or twist the bridge upon its tracks. If we assume that the force applied at M be sufficient to move the bridge one foot forward, it will be seen that the guide sheave E will be moved correspondingly, and that in doing so a length of the rope X equal to the amount of travel of the bridge must be passed around the guide sheave E in the direction of the arrow S. The length of cord required for this must of course be drawn from that portion of the rope X located between the sheaves E and F, and in like manner, therefore, an equal amount must be supplied by the length of the cord X which is located between the sheave F and the abutment X′. But this latter can only be obtained by the movement of the sheave F a corresponding distance, namely one foot, towards the point X′; from which it follows that a force acting to move the bridge one foot forward at and in the direction of the arrow M, must produce a corresponding and equal force, acting through the guide sheave F and the cord X, to *pull* the opposite end of the bridge an equal distance in the same direction, thus neutralizing the resistance indicated by the arrow N. Should the power be applied at the point and in the direction indicated by the arrow N, the same result will ensue in the reverse order, the cord X and pullies F and E acting to overcome the resistance M. So, also, should the force be applied at the point M, but in a direction contrary to that above supposed, the parallelism of the bridge with its tracks will be preserved by the cord Y, acting around the sheaves D and F in a manner precisely similar to the action of the cord X, as above explained.

It thus follows that, by means of the two cords X and Y, and the four sheaves D, E, F, F, the bridge is kept always square to its tracks, and compelled to move in perfect parallelism with them, irrespective of the point at which the propelling power is applied, and independently of the different resistance to traction offered by the trucks at the opposite ends of the bridge, which may result from inequality of loads or from any other causes.

The extreme simplicity of this device in only equaled by the absolute perfection with which it performs its work. A light wire rope, of ¼ or ⅜ inch diameter, is amply sufficient for squaring the largest bridge, and is also available for propelling it, in the manner explained hereafter. The system is equally applicable to bridges of large or small capacity, and of short or wide span. It is already in use in cranes of 25 tons capacity, and of more than 70 feet span. Its parts are few and simple, and the motions slow, corresponding with the speed of the bridge, so that the wear of the parts is inappreciable. The device is equally applicable to machines for operation by hand or by power, and its compactness and simplicity are in striking contrast to the devices previously used, which latter have usually consisted of long transverse shafts, with gearing in both trucks, and, for large cranes, a longitudinal rack adjacent to each of the side tracks, and of equal length.

BRIDGE MOVING DEVICE FOR TRAVELING CRANES.

The mechanism shown in Fig. 22 below comprises the bridge squaring device described in the preceding chapter, with the addition of a grip wheel applied to each of the fixed squaring cords X and Y, so that they may be seized or gripped and thereby made available for *pulling* the bridge in either direction desired.

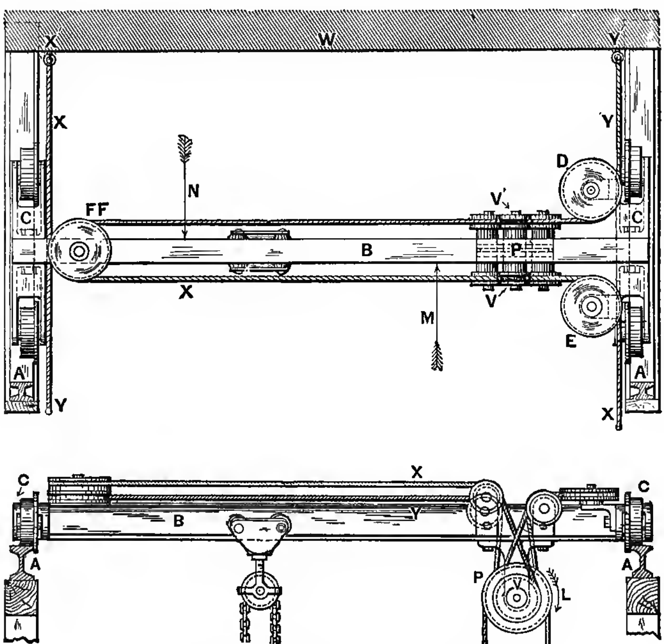


FIG. 22.—Device for Squaring and Propelling Bridges.

In Fig. 22 the bridge B rests and moves upon the longitudinal tracks AA, and is maintained in parallelism with them by means of the fixed squaring cords X and Y, as explained

before. Attached to the right hand end of the bridge, and, for convenience, located beneath it, is a frame carrying a shaft upon which are fixed the three wheels V, P and V′. The wheel P, which is fixed to the shaft midway between the wheels V and V′, carries the endless hand chain or rope Q, which reaches to within a convenient distance of the floor below. The peripheries of each of these wheels contains a V-shaped groove of such form that the rope, in passing around the wheel, presses into it without touching its bottom, and is thus firmly gripped between the converging sides of the groove, so that if the grip wheels are rotated they tend to *pull* the rope passing around them in one direction or the other, according to the direction in which they are turned.

Attached to the bridge, immediately over the wheels above referred to, are guide sheaves by which the two fixed cords X and Y are deflected downward and into engagement with the grip wheels V and V′. The cord Y passes over its guide sheaves directly to and from the grip wheel V′, while the cord X, on the contrary, in passing to and from the grip wheel V is crossed. It follows, therefore, that the rotation of the grip wheels V and V′ in the *same* direction causes *opposite* parts of the cords X and Y to be pulled. If now the hand rope Q be pulled so as to rotate the shaft carrying the several grip wheels in the direction of the arrow L, the grip wheel V′ will be caused to pull that part of the cord Y which, after passing around the sheave D, is secured to the wall at Y′, while at the same time the grip wheel V, by reason of the crossing of the cord X as it leads on to it, will be caused to pull upon that part of the cord X which, after passing around the sheave F, is made fast to the wall at X′. It will thus be seen that the rotation of the shaft in the direction of the arrow L will cause an equal and simultaneous pull to be exerted from the two ends of the bridge upon the abutments X′ and Y′, and the bridge will accordingly be propelled or *pulled* in the direction of the arrow M.

In considering the action of this apparatus it is to be noted that all the features of the squaring device illustrated in Fig. 21, and already described, are fully and effectively retained, while at the same time they are further utilized for the additional

purpose of propelling the bridge longitudinally, the additional mechanism required for this purpose being very simple. Moreover, the action of the propelling mechanism is such as to simultaneously *pull* each end of the bridge in the same direction, at the same time and at equal speeds, so that it has no tendency to strain the bridge out of squareness with its tracks.

For purposes of illustration, the mechanism illustrated by Fig. 22 is of the simplest possible form, with all details removed except such as are essential to a clear understanding of the action of the squaring and moving devices.

SQUARING, AND BRIDGE AND TROLLEY MOVING DEVICE FOR TRAVELING CRANES.

In Fig. 21 has been shown the Weston system of fixed wire cords as arranged to constitute a simple squaring device for the bridge of a traveling crane. In Fig. 22 the same device is illustrated with additional provision by means of which it is utilized for propelling the bridge longitudinally upon its tracks, In Fig. 23 (next page) is shown a third application of the system which, while retaining both of the functions previously described, embodies the additional one of provision for causing the travel of the trolley upon the bridge in either direction desired.

In Fig. 23 the bridge B rests and moves upon the longitudinal tracks AA, and is maintained in parallelism with them by means of the fixed squaring cords X and Y, as explained before. Moving transversely upon the bridge is the trolley T, from which the load is suspended. Upon each side of the trolley is a grip wheel V V′, over which the cords X and Y are caused to pass by the small guide sheaves UU on the trolley. The peripheries of the several guide sheaves are all provided with a concave groove of a radius slightly greater than that of the wire rope, so that the latter passes freely over them without binding. The periphery of the grip wheels V V′, on the other hand, contains a V-shaped groove of such form that the wire rope, in passing around the wheel, presses into the groove without touching its bottom, and is thus firmly gripped between the converging sides of the groove, so that if the grip wheels are rotated they tend to *pull* the rope passing around them in one direction or the other, according to the direction in which they are turned.

If now the grip wheels V and V′ be both rotated simultaneously and at equal speeds in the direction of the arrow L, it is evident that they will each draw or pull upon that portion of each of the ropes X and Y which lies between the trolley and the right

hand end of the bridge. But as the rope Y is attached to a fixed abutment at Y′, and the corresponding end of the rope X to a similar abutment, they cannot be drawn towards the trolley, and therefore the trolley must follow them, so that the simultaneous rotation of the two grip wheels in the direction of the arrow L tends to *move the trolley* in the direction of the arrow R, the

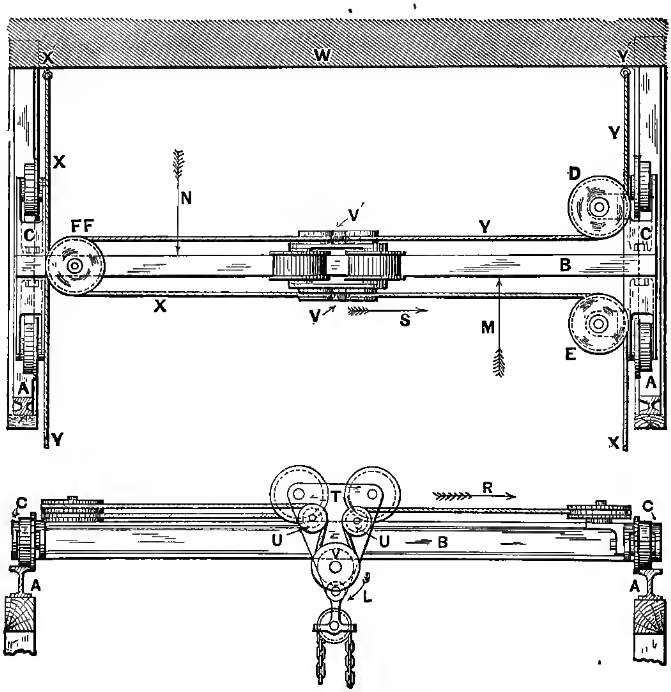


FIG. 23.—Device for Squaring and for Propelling Bridges and Trolleys.

bridge remaining stationary. A reverse motion of the grip wheels V and V′ would of course tend to move the trolley in a direction contrary to the arrow R. If, however, the grip wheel V′ be rotated in the direction of the arrow L, and the grip wheel V in the contrary direction, the effect of the former will be to pull upon the cord Y, and through it upon

its abutment Y′, while the effect of the latter will be to pull upon the cord X, and through it upon its abutment X′. The grip wheels being thus rotated in contrary directions, but at equal speeds, the bridge will be propelled towards the wall W by a direct pull upon the fixed abutments X′ and Y′ transmitted through the cords X and Y. It is immaterial, however, that the grip-wheels be rotated with equal power and at equal speeds, for any inequality, either of the power applied or the resistance encountered by the trucks, simply brings into play the squaring properties of the fixed cords, and distributes the propelling power equally between the opposite ends of the bridge. If only one of the grip-wheels be rotated, as, for example the wheel V′ in the direction of the arrow L, the effect is to pull or draw that portion of the cord Y which lies between the trolley and the abutment Y′. The effect of this, if the trolley moves much more easily than the bridge, will be to draw the trolley towards the right hand end of the bridge, the latter remaining stationary. If the bridge moves more easily than the trolley, the effect will be to draw the bridge towards the wall W, the trolley remaining stationary. If the resistance of both bridge and trolley be equal, the motion will be equally divided between them, so that, if one foot of the rope be passed over the grip wheel V′ by its rotation, the trolley will move six inches upon the bridge, and the bridge move six inches upon its tracks, the resultant motion of the load being a diagonal of 45 degrees. Under all conditions the squaring device performs its function equally well, and insures the parallelism of the bridge with its tracks at all times and under all inequalities, either of load or of resistance.

The mechanism illustrated in Fig. 23 is purposely of a very simple form in order to more clearly illustrate the action of the device. In traveling cranes for operation by hand the grip wheels are usually rotated by endless ropes or chains, operated by the workman from the floor below, while in cranes operated by power the motive force is made available for rotating the grip-wheels through the instrumentality of Weston-Capen Clutches, operated by suitable hand levers.

The above illustrations and descriptions will, it is hoped,

make perfectly clear the great simplicity and absolute efficiency of the Westom system of fixed cords for squaring and propelling the bridges of traveling cranes. As already stated, the invention is equally applicable to cranes operated by hand or by power. It has long since passed from the experimental stage and is now in daily use upon numerous cranes of various types and of all capacities. Under all conditions it is found to do its work certainly, quietly and perfectly. Its introduction marks a new departure in the construction of traveling cranes, and by reason of its simplicity and economy of construction greatly enlarges the adaptability of the traveling crane, and makes it available for numerous uses to which it has not heretofore been possible to apply it.

TROLLEY TRAVELING MECHANISM.

In jib, traveling and other cranes provided with trolleys, some mechanism is necessary to effect the longitudinal motion of the latter. This may be accomplished by a rack and pinion, or by an endless chain or rope attached to the trolley and operated by a driving-wheel at one end, with a suitable guide sheave for returning it at the opposite end. All devices of this kind are entirely distinct from the hoisting gear of the crane and are operated independently. Under some conditions a separate mechanism for this purpose is desirable, but usually this is not the case. We illustrate below the system adopted in most of the Weston Cranes which, as will be seen, effects the motion of the trolley by means of the devices employed for hoisting and lowering, and thus obviates the need of any separate mechanism.

Fig. 24 represents a Weston Jib Crane with combined hoisting and traversing gear. Referring to the figure, A, B and C are respectively the jib, mast and brace of a jib crane. D is the running block, J the trolley carrying the sheaves which form the upper block, F, G and H guide sheaves by which the two parts of the chain are directed to the two housings attached to each side of the mast near its base, and containing the operating mechanism. Each of these latter is a complete and independent hoisting machine, operated respectively by the cranks or handles L and M, the shafts of which extend through the housings, so that cranks may be applied upon either or both ends of each shaft. The chain X passes from the left hand housing over the guide sheave G, then around the guide sheave F, and so to the trolley J, where it passes over another sheave and extends downward to the block D. In like manner, the other part Y of the chain passes from its housing over the sheave H directly to the trolley, and so down to the block. By turning the crank M so as to haul in the part Y of the chain, the load will be raised, and, in like manner, by turning the crank L so as to haul in the part

X of the chain, the load will be raised. By simultaneously turning both cranks so as to haul in both parts of the chain, the load will be raised at double speed. By rotating either or both of the cranks in the opposite direction, the opposite motions will be effected, and the load will be lowered at single or double speed. By slipping both pinions on their shafts so that they

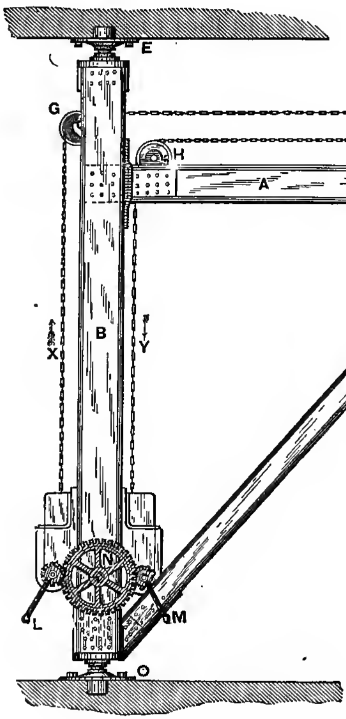


FIG. 24.—Mechanism for Moving Trolleys.

engage with the large spur wheel N between them, motion of one pinion will be communicated to the other at an equal speed, *but in a contrary direction*, the result of which will be to cause the part Y, for example, to be hauled in and the part X to be paid out (as indicated by the arrows on the cut) at exactly equal speeds. The consequence of this will be to cause the trolley J to

be pulled toward the mast by the part Y of the chain, while at the same time the part X of the chain will be released or paid out at the same speed, and thus oppose no resistance to the inward motion of the trolley. During this time the parts of the chain lying below the trolley, and between it and the block D, are not disturbed, so that the load remains suspended upon them, and no unnecessary friction or wear of the chain is caused by needless rendering of the chains over the sheaves in the trolley and block. It will thus be seen that, when it is desired to move the trolley in either direction, the two parts of the chain which lead from the trolley back to the operating mechanism, are utilized to effect its motion, thus dispensing with the need of any separate mechanism for this purpose, while at the same time the rest of the chain remains stationary and is not subject to wear.

In traveling cranes the same result is obtained, save that, in some cases, the horizontal parts of the chain pass directly from the trolley to the operating mechanism without being deflected by guide sheaves, although in most cases it is found best to place the mechanism beneath the bridge, in which case the action is identical with that above explained, except that the operating mechanism is close to the guide sheaves G and H instead of at some distance below them, as in the case of a jib crane. In power cranes, of whatever type, this arrangement is equally applicable, the only difference being that the several motions are effected by power, transmitted through suitable clutches, instead of by manual effort applied to the cranks or hand chains.

A prominent and most valuable feature of this construction consists in the even distribution of wear over all parts of the chain. Referring to Fig. 24, it may be explained that the two parts X and Y of the chain, after passing through the housings at the foot of the mast, enter a suitable box or receptacle, and are there united, so that the chain is endless, although for clearness of description its two parts or sides are distinguished in the foregoing description by the letters X and Y. It is found in practice that, in using cranes thus constructed, the operator frequently changes from one crank to the other, so that when hoisting, the part Y, for example, will be hauled in, while, when it is desired to lower or

to cause travel of the trolley, the part X may be paid out, and in this way the whole length of the chain is gradually passed through the operating mechanism and each of its links subjected to equal wear. No special attention need be given to the attainment of this end, as the varying requirements of use secure its attainment without any attention on the part of the operator, and all parts of the chain are ultimately subjected to practically equal wear. Where the chain is wound upon a drum, on the contrary, certain parts of the chain will necessarily receive most of the wear, and will become weakened and unsafe while the rest of the chain may be perhaps almost unimpaired. This equal distribution of wear over the entire length of the chains, which is accomplished by the Weston system of construction, thus gives great durability to the chains, and proportionately increases their safety. It may be noted also that, as the parts of chain between the trolley and the block are not disturbed during the motion of the trolley, a much smoother and quieter action occurs than when these parts of the chain are compelled to render over the sheaves, as is the case with the ordinary construction. This feature is of particular value in foundry work, and is valuable in all cases as tending to diminish the wear upon the chain, and thus prolong its life.

GEARING OF JIB CRANES FOR OPERATION BY HAND.

The mode of operating the hoisting and traversing mechanism of the larger sizes of the Weston Jib Cranes is fully explained in the preceding article. The details of the gearing whereby these several motions are effected are as follows.

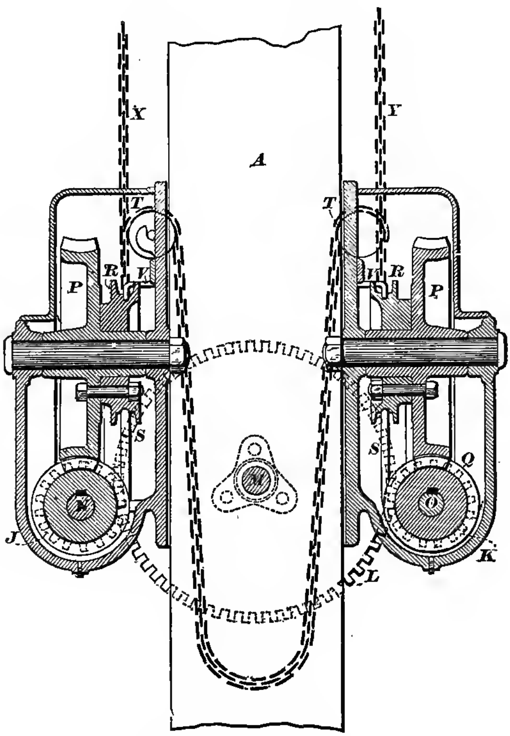


FIG. 25.—Gearing of Jib Crane.

Fig. 25 is a cross-section taken at the foot of the mast of a large jib crane, as illustrated in Part III. A is the mast, to each

side of which is bolted a housing containing the gearing for operating the two parts X and Y of the main hoisting chain. Each of these housings is provided with a horizontal shaft, revolving upon which is the worm wheel P, the hub of which covers the entire length of the pin or shaft between its bearings. Fitted over the hub of this wheel, and bolted securely to it, is the pocketed chain wheel R, provided with the chain stripper V, and also with a suitable chain guide S, substantially in the manner illustrated in Fig. 1. The chain wheel is made separately from the worm wheel to admit of easy removal and renewal when worn out. Referring now to the right hand housing in the cut, O is the crank shaft extending through the housing at right angles to the worm wheel shaft above. Q is the worm, fitted upon the shaft O at its center, and gearing into the worm wheel P. K is a spur pinion, fitted to one end of the shaft O, and capable of sliding longitudinally thereon. T is a small guide sheave over which the slack of the chain falls after passing around the lower semi-circumference of the chain wheel R. The arrangement of the opposite or left hand housing, and its contained gearing, is the same as that just described.

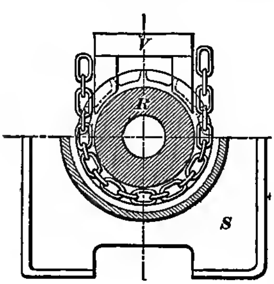


FIG. 26.

Fig. 26 is a detail view of one of the chain wheels R, with the chain guide S and stripper V, showing the manner in which the chain is guided during its contact with the wheel, and the provision, by means of the stripper V, for compelling it to leave the wheel R at the proper point in whichever direction the wheel is being turned. The slack part of the chain, after passing over the guide sheave T, falls into a receptacle between the housings at the foot of the mast. The chain being endless, the two parts X and Y come together in the receptacle just referred to, and are there united, the amount of slack chain contained in the box varying with the position of the running block.

Fig. 27 is a horizontal cross-section taken through both

housings and the mast of the crane, the several parts being designated by the same letters as in Fig. 25. M is a shaft parallel to the crank shafts O and N, extending through the mast and carrying at one end the large spur wheel L. The pinions J and K, as previously explained, are arranged to slip upon their shafts so as to bring them into or out of coincidence with the intermediate wheel L. As shown in Fig. 27, the pinion K is engaged with the wheel L, and the pinion J is disengaged. If now the crank be applied to the shaft N and turned in the proper direction,

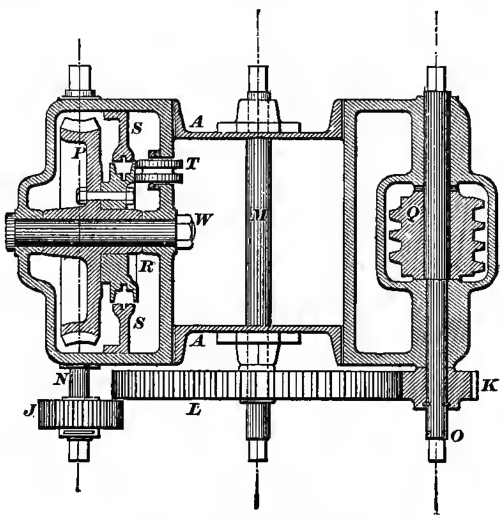


FIG. 27.—Gearing of Jib Crane.

the chain X will be hauled in and the load raised. The same effect will result from rotation of the shaft O. If both be turned simultaneously, hoisting will be effected at double speed. By applying the crank to the shaft M, motion will be communicated, through the wheel L and pinion K, to the shaft O, and hoisting will occur at a rapid speed proportionate to the relative diameters of the wheels L and K. Three speeds are thus obtained for hoisting, all of which are equally applicable to lowering by reversing the motion of the cranks.

To effect travel of the trolley, in the manner explained in the preceding article, both pinions J and K are slipped into engagement with the wheel L. By then turning either of the shafts N or O in the proper direction, one part of the hoisting chain, X for example, will be hauled in, and the opposite part, Y, paid out at equal speeds, the effect of which is to cause the trolley to move horizontally upon the jib. By applying the crank to the shaft M, these motions are accelerated, and a rapid movement of the trolley results.

Two cranks are furnished with each crane, and it is to be noted that the construction admits of the employment of both cranks upon any one of the shafts M, N, or O, so that the entire energy of all the men employed upon the crane is transmitted through that shaft, while, if more rapid action is desired, one of the cranks may be placed upon the right hand end of the shaft N and the other upon the opposite or left hand end of the shaft O. In either case the two shafts, being on opposite sides of the crane, do not in any way interfere with one another, and are thus always available for the full number of men who can effectively be employed upon them.

The compactness and simplicity of this mechanism will be apparent from the foregoing description. The entire operating mechanism of the crane consists of two worm wheels and worms, and of the spur wheel L with its two pinions. The worm wheels and worms are entirely contained within the two housings, the upper parts of which latter are arranged to lift off to give access to the gearing. Each of the worms runs in an oil well, thus insuring perfect lubrication, and each of these wells is provided with a drainage tap at the bottom to draw off the lubricant when desired.

GEARING AND CLUTCHES OF POWER TRAVELING CRANES.

As stated elsewhere, the main chains of the Weston Power Traveling Cranes are arranged in substantially the same manner as on the jib crane illustrated and described in the two preceding articles. Briefly described, the arrangement is as follows: The chain is endless, and after passing over the sheaves in the bottom block and in the trolley, one of its parts is carried directly to the crab containing the operating mechanism, while the other part passes first in the opposite direction to the other end of the bridge, where it is returned around a guide sheave, and thence carried, parallel to the first part, back to the crab. The two parts of the chain thus enter the crab side by side. Hoisting is effected at one speed by pulling in either part of the chain, and at double speed by pulling in both parts simultaneously. Lowering is effected also at two speeds, by the contrary motions. By hauling in one part and paying out the other simultaneously, at equal speeds, the trolley is caused to travel on the bridge. In order to effect the several operations of the crane, therefore, it is necessary that the mechanism should be capable of hauling in or paying out either one of two separate chains or ropes independently of the other, and of paying out or hauling in both ropes or chains simultaneously, and also that it should be capable of paying out the one and hauling in the other simultaneously and at equal speeds. The mechanism by which these apparently complex movements are obtained is illustrated in the following figures.

Fig. 28 is a plan or top view of the reversing mechanism of a Weston Power Traveling Crane, with the surrounding crab frame or housing removed so as to clearly expose the mechanism. A is the primary shaft, carrying the rope driving wheel B, by means of which it is constantly driven in one direction and at uniform speed. C and D are the worm shafts, lying parallel with A and slightly below it. The latter shafts carry respectively

the worms M and K, gearing into the worm wheels N and L. The latter rotate upon a transverse shaft Z, and have screwed to

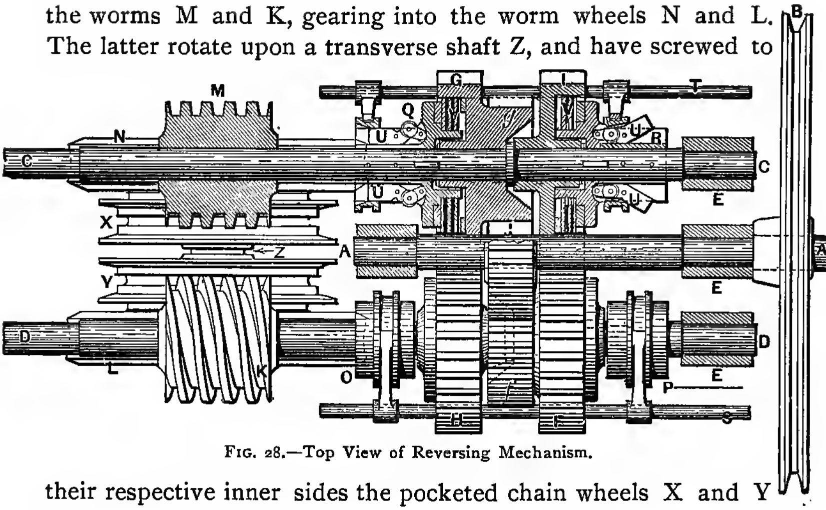
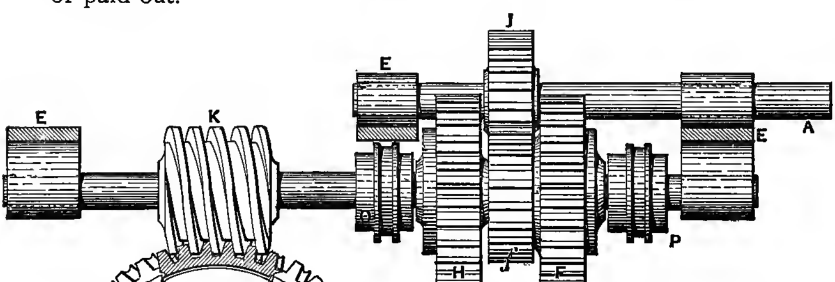


Fig. 28.—Top View of Reversing Mechanism.

their respective inner sides the pocketed chain wheels X and Y by means of which the two parts of the chain are to be hauled in or paid out.



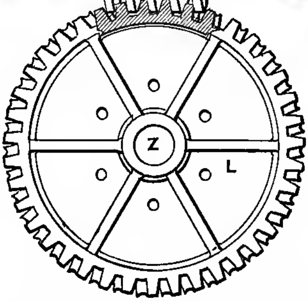


Fig. 29.—Side Elevation of Reversing Mechanism.

Fig. 29 is a side elevation of the mechanism shown in Fig. 28, similar letters of reference indicating similar parts in both views.

Fig. 30 is an end view of the three shafts A, C and D, with their several gear wheels. By reference to each of the three views above given, the following

explanation of the several parts of the mechanism will be easily followed.

Attached to the shaft A and revolving with it is the spur pinion J. On the shaft D are two spur wheels F and H, and on the shaft C two corresponding spur wheels G and I. Each of these four spur wheels can revolve freely on its shaft, or the shaft within the wheels, without any motion being communicated from one to the other. Cast in one piece with the wheel F is the pinion *f*, and with the wheel G is the pinion *g*. The spur pinion J on the driving shaft A is always in gear with the pinions *f* and *g*.

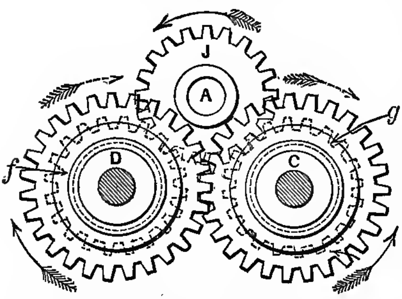


FIG. 30.—End View of the Three Shafts of the Reversing Mechanism and their Connecting Gears.

By reference to Fig. 30 it will be seen also that the spur wheels F and I are always engaged together, and, in like manner, the spur wheels G and H, whence it follows that the wheels F and I are always running in contrary directions, as are also the wheels G and H, and, therefore, that F and G must run in like directions, and H and I in like directions, but contrary to F and G.

We thus have on each of the shafts C and D two wheels or pinions, one of which rotates to the right and the other to the left, but both revolving freely on their shafts, so that no motion is communicated to the latter.

Within each of the four wheels F, G, H and I is a Weston-Capen Clutch (see page 47), by means of which each of the four wheels may at will be clutched to its shaft, so that the motion of the wheel will be imparted to the shaft. The clutches within the wheels G and I (see Fig. 28) are operated by the shipper rod T, and the clutches of the wheels F and H by the shipper rod S. The arrangement of these shipper rods is such that each may be moved independently of the other, but that the motion of either rod in a direction proper to engage one of its clutches effects the

release of its other clutch, and *vice versa*, so that only one of the two revolving wheels on each of the shafts C and D can at any given time be clutched to its shaft. By a simple arrangement of levers the operator is enabled to control both shipper rods, and by means of them to cause the shafts C and D to rotate in either direction independently or simultaneously, as desired, and thus to cause the chain wheels X and Y to haul in or pay out either or both of the two parts of the chain, or to haul in one part and pay out the other simultaneously and at equal speeds. To effect the travel of the bridge, by means of the fixed cable system, a third shaft is attached to the crab or housing, parallel with the shaft D and provided with two loose spur wheels gearing respectively with the wheels F and H, so that they rotate in opposite directions. A pair of Weston-Capen Clutches, and a shipper arrangement similar to that above described, enable either of these wheels to be clutched to this third shaft, thus driving it in either direction desired, and thereby moving the bridge. This pair of clutches is controlled by a separate lever. By means of the two levers first referred to six movements are obtained, viz.:

Hoisting at slow speed;
Hoisting at double speed;
Lowering at slow speed;
Lowering at double speed;
Travel of the trolley inward;
Travel of the trolley outward.

By means of the third lever two other movements are obtained, viz.:

Travel of the bridge to the right;
Travel of the bridge to the left.

In the larger cranes back gearing is usually added in order to give a slower speed for heavy loads. This involves the addition of only one more shaft and two small spur wheels with clutches, and the back gearing is controlled by an independent lever. This addition gives twice as many speeds as before and enables twice as many, that is sixteen, distinct movements to be

made. Thus arranged, the machine has capacity for the following changes of movement.

Hoisting, four speeds ;
Lowering, four speeds ;
Bridge travel, in either direction, two speeds ;
Trolley travel, in either direction, two speeds.

The entire mechanism, by which these sixteen changes of movement are obtained, is contained within a crab or housing which, in the case of a 20-ton crane, measures only 24 by 48 by 31 inches, and which is attached permanently to the under side of the bridge at one end. The compactness, simplicity and perfect reliability of this mechanism can only be fully appreciated by actual examination. By reason of its compactness the greatest economy of space is secured, and a longer motion of the trolley, and greater height of hoist at the operating end of the bridge, are obtained than is otherwise possible. All of the important mechanism of the machine is in this way concentrated at the operating end, within easy view and reach of the operator, and both the bridge and the trolley are relieved from the numerous and cumbersome shafts, gearing and other attachments which have been necessary in former types of cranes.

BRIDGE TRUCKS.

The bridges of traveling cranes are supported at each end by trucks carrying the wheels which travel upon the longitudinal tracks. The construction of these trucks has been a subject of careful study, and as a result the designs illustrated below have been adopted in the Weston Cranes.

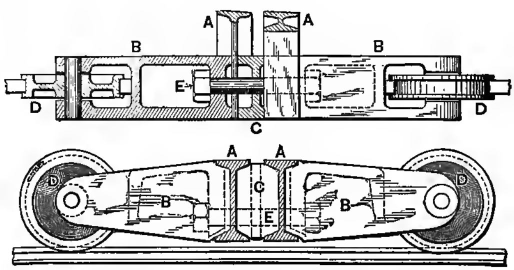


FIG. 31.—Truck for I-Beam Bridge.

Fig. 31 represents the end-truck of a bridge composed of two solid I-beams placed side by side. This construction of bridge is employed in traveling cranes in which the span and the load to be lifted are within limits which permit of it, as explained in the succeeding article. Referring to the cut, AA are the two I-beams composing the bridge, BB are two cast iron brackets, C a cast iron separator between the beams, and E a bolt holding all of these parts in engagement. The inner ends of the brackets BB are fitted accurately to the contour of the sides of the I-beams, so that, when the parts are drawn together by the bolt E, the brackets are rigidly secured against rotation or displacement in any direction. The truck-wheels DD are double-flanged, and are sufficiently separated to give a proper wheel-base. Their axles are secured to them and turn with them, the journals being formed in the two sides of the bracket B. The strains resulting from a load upon the bridge are resolved into compres-

sion upon the upper portion of the brackets BB, which is resisted by the metal of the bracket, and into tension at the bottom, which in turn is carried by the bolt E. The beams forming the bridge extend through the truck to its outer side, thus overlapping the longitudinal track, so that the breakage of any of the parts of the truck would merely result in allowing the beams AA to rest upon the track.

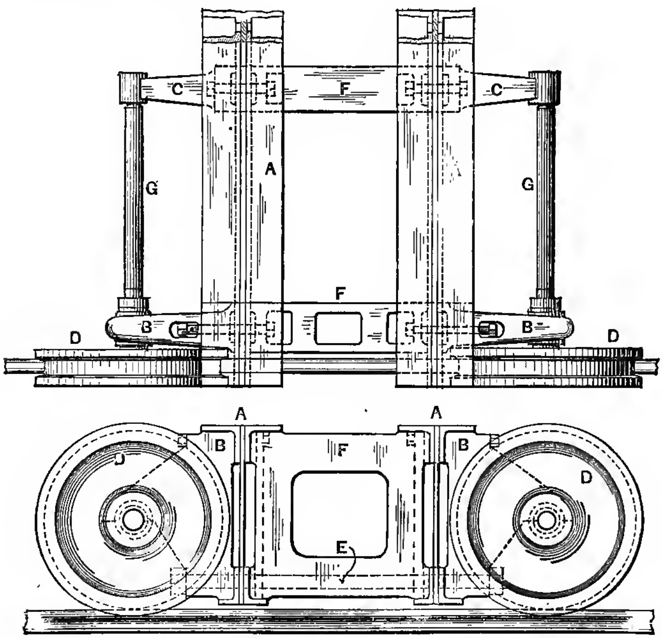


FIG. 32.—Truck for Plate Girder Bridge.

In Fig. 32 is represented the form of end-truck used in large traveling cranes, the bridges of which are formed of plate girders.

In this case AA are the two girders composing the bridge, and BB the brackets for supporting the truck-wheels. In order to economize space between the ends of the bridge and the walls of the building, the truck-wheels DD are overhung, and their axles

GG are extended to reach bearings in the brackets CC. FF are separators between the girders and in line with each pair of brackets. In this case, as in the one above described, the effect of the load is to cause compression in the upper portions of the brackets BB (which is resisted by the metal composing the brackets), and tension at the bottom. The latter strain is borne by the bolt E, which passes through both brackets, both girders, and the separator F, and serves to rigidly hold all of these several parts in engagement. The upper ends of the brackets are bolted through the girders to the separator F by smaller bolts, as shown in the cut, their purpose being to securely locate the several parts in the proper relative positions. The strains caused by the load are chiefly carried by the brackets BB, which are much heavier than those at CC, and which are provided with spherical bearings of bronze, so arranged as to permit the wheels to adapt themselves to any irregularities of the track. It will be seen that the girders AA overlap the longitudinal track, so that any failure of the trucks would simply permit the bridge to rest upon the tracks.

The methods of construction illustrated above, while novel, are believed to be more simple and secure than any heretofore employed. Wrought iron is employed to resist tensional strains, and the construction is such that these strains are parallel with the axis of the bolt in each case, and no bending or sheering strains are introduced. The cast iron members are so formed as to best resist the strains they are subjected to, and the construction throughout is exceedingly simple.

FRAMES AND GIRDERS.

For the reasons stated in Part I, construction in iron has been adopted almost exclusively for the frames, girders, etc., of the Weston Cranes. The great variety of structural shapes of iron which are now obtainable, and the increasing capacity of our rolling mills to produce shapes of large area and of great length, have greatly simplified and cheapened the building of iron crane frames and girders of moderate sizes. Wherever the dimensions of the work admit these irons are employed. In larger machines resort is had to plate girders, as described below, while for the columns of large pillar cranes and similar machines cast iron in single pieces is employed.

The frames of small jib cranes may frequently be constructed by using a single iron for each of the principal members, as shown by the illustrations in Part III, in which case the I-beam section is found best. For larger sizes, say from 3 tons upwards, a double frame, each of the principal members being composed of two channel irons, is found better.

The latter construction is shown in outline in Fig. 33, in which the jib A, mast B, and brace C are each composed of two channel irons, separated sufficiently to give proper room for the attachment of the mechanism and to permit the main chains, depending from the trolley, to pass between the two irons forming the jib. The best and most economic construction requires that the brace C shall intersect the jib A at a distance from the mast equal to four-fifths of the extreme effective radius of the crane, that is, that the distance X in the cut should be one-fourth as great as the distance Y. When for any reason it is necessary that the brace intersect the jib at a point nearer to the mast, as, for instance, at C′, as shown by the dotted lines in cut, a much greater depth is necessary in the irons forming the jib, and frequently also in those composing the mast. It is customary, therefore, to proportion the several parts as shown

in the cut, unless otherwise ordered. Where it is possible to obtain greater height of mast above the jib, as indicated by dotted lines at M, a suspension-rod N may be substituted for the

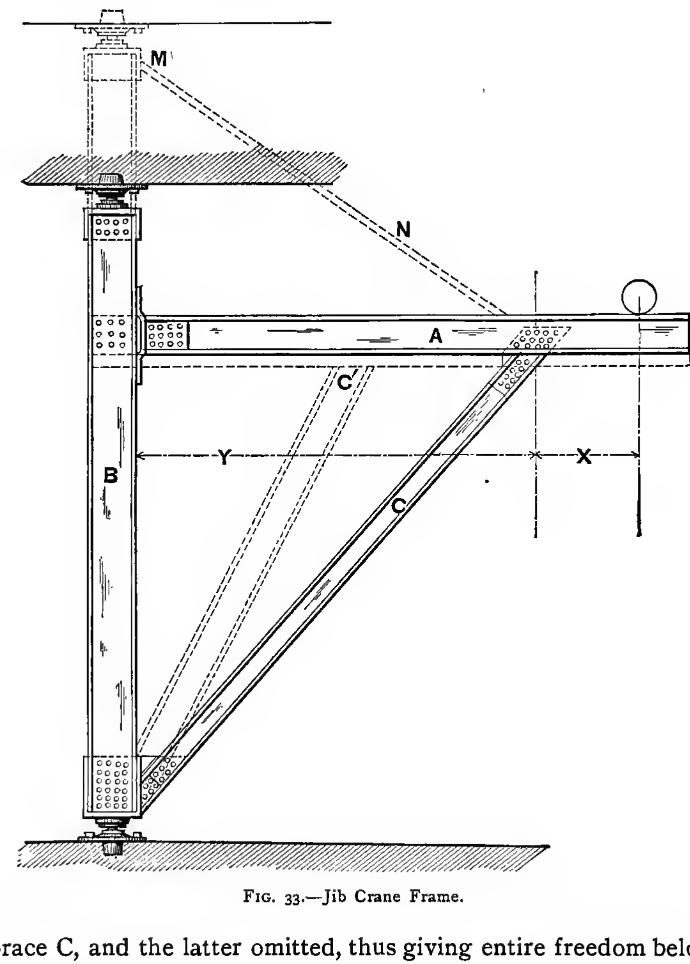


FIG. 33.—Jib Crane Frame.

brace C, and the latter omitted, thus giving entire freedom below the jib. The intersections of the several members of jib cranes thus constructed are best united by the overlapping of the web

of one part upon the other, and by gusset-plates, all firmly fastened by proper riveting.

Fig. 34 represents the transverse section of the bridge of a traveling crane of medium size, which consists of two I-beams placed side by side, with separators between, and firmly bolted together. The trolley-rails are placed on top of the beams, and the construction is such that the chains from the trolley pass outside of the bridge. Where the load to be carried is too great, or the span too wide to permit of the use of rolled beams, plate girders, built as shown in Fig. 35, are used.

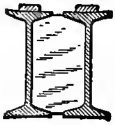


FIG. 34.

This girder consists of a thin plate of wrought iron, with heavy flanges at its top and bottom edges, each composed of a pair of angle irons riveted through the plate and to each other. Each of the angle irons forming the top and bottom flanges of such girders is continuous, and rolled in a single piece. At proper intervals vertical struts, formed of angle iron, are interposed between the top and bottom flanges to reinforce the web of the girder, and a proper rail is placed on top for the trolley to run upon. The bridge is formed by two of these girders, placed side by side, and in large cranes the hoisting chains pass downward from the trolley between the girders, which latter are separated sufficiently to enable the running block to rise between them.

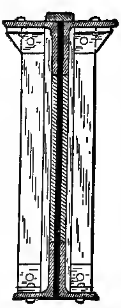


FIG. 35.

In proportioning the frames and girders of the Weston Cranes, such dimensions are adopted as will insure a factor of safety of *six* throughout, that is, such that the strains developed, with the maximum load suspended at the center, or point of greatest strain, shall not exceed one-sixth of the breaking strength of the material employed. We state the case in this way for the reason that it is still customary with most engineers to make such calculations upon the basis of an assumed "factor of safety." The best and latest practice, however, is to proportion the parts with reference to the elastic strength of the material employed, and it is the present practice, so far as possible, to give such dimensions to the frames and girders of

the Weston Cranes, that under no condition shall any of their members be strained to within 50 per cent. of the elastic limit of the material. At all intersections of members, and at points of attachment with wrought or cast iron parts, an excess of strength is always provided to allow for the weakening of bolt and rivet holes and other contingencies. Special attention is given to securing unusual strength and safety in these details of the Weston Cranes, all of which are based upon exact and careful calculation. A comparison of one of these cranes with most others of equal nominal capacity will show much difference in the amount and disposition of material employed, so that, although the latter may possibly lift their full nominal load without breaking down, the former may be relied upon to do so always with absolute safety. Doubtless a load of 10 tons could be lifted with a 5-ton Weston Crane without disabling it; but, in executing a contract to furnish a Weston Crane of 10 tons capacity, the builders furnish one proportioned as above explained, and of a strength such as to make it absolutely safe for its intended work.

BRIDGES AND TRESTLES OF TRAVELING CRANES.

The method of building the girders composing the bridges of traveling cranes, and the mode of constructing their trucks, have been already described. It remains to describe the bridge as a whole and to show the mode of supporting it.

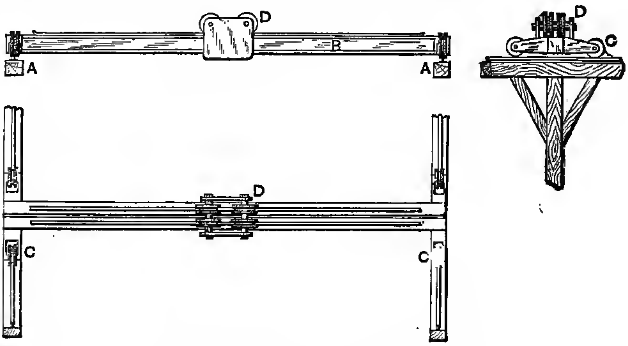


FIG. 36.—Bridge of Hand Traveling Crane.

Fig. 36 represents a plan, with end and side elevations, of the bridge of a hand traveling crane composed of two I-beams, as shown in Fig. 34. In this case the bridge B is carried at each end by the trucks CC traveling upon a suitable iron or steel rail placed on the trestles AA. Ordinarily the longitudinal tracks are supported on wooden trestles as shown in the cut, but they may also rest on wooden stringers placed upon a brick wall, or be carried by brackets projecting from the latter.

Fig. 37 is a plan of the bridge of a large power traveling crane, with end and side elevations of the same. BB are two girders, each built as shown in section by Fig. 35, and CC are the end-trucks carrying the bridge, the construction of which is shown by Fig. 32. The longitudinal rails rest directly upon wooden stringers, which in turn are supported by suitable posts and braces.

The construction of trestles shown in Figs. 36 and 37 is the one ordinarily resorted to. In some cases, however, wrought iron girders are provided for supporting the longitudinal tracks, and in others the stringers on which the tracks rest are carried directly upon a brick wall, or upon suitable brackets projecting therefrom. In all cases it is important that such stiffness be given to the stringers supporting the longitudinal tracks that there shall not be excessive deflection when the load passes over them. In determining their dimensions it should be remembered that each trestle carries one-half of the weight of the crane, and is liable to carry almost the whole of the live load. Thus, if the weight of the crane itself be 6 tons, and the maximum load to be carried be 10 tons, when the load is at the center of the bridge the truck at either end will receive a total load of 8 tons, and the trestle supporting the track on which the truck

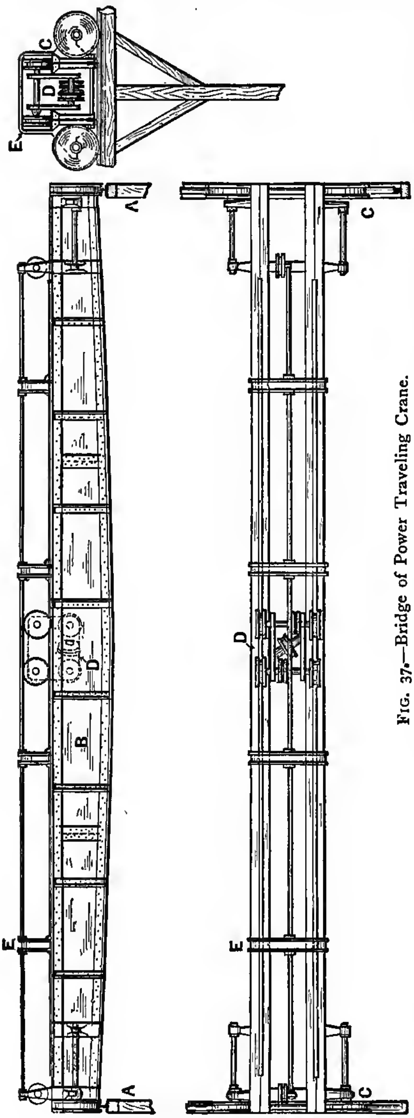


FIG. 37.—Bridge of Power Traveling Crane.

is to run should be proportioned to safely carry the whole load distributed upon the two wheels of the truck, the load on each of the latter in the above case being 4 tons. As, however, the maximum load may be suspended from one end of the bridge, either truck is liable to receive the whole of the load (nearly), say, in the above case, 10 tons, in addition to one-half the weight of the bridge, say 3 tons, making in all 13 tons, or 6½ tons on each wheel, and this fact should be kept in view in designing the trestles for supporting such a crane.

Stiffness, as well as ultimate strength, is important in the trestles for the longitudinal tracks, since deflection of the tracks between supports would give an undulating line, so that the crane would at one time be upon a down-grade and at others be compelled to climb an up-grade. The latter would of course greatly increase the traction of the crane and cause unnecessary strain upon all of the driving gear.

One of the chief merits of traveling cranes as compared with jib cranes is that they entirely avoid the severe lateral strains upon the walls and roof of the building which exist where heavy jib cranes are employed. The entire weight of a traveling crane and its load rests directly upon the longitudinal tracks and their supports, so that vertical strains only have to be considered. These are usually and preferably resisted by suitable posts extending to the ground, so that the walls or frame of the building are unaffected by the loads upon the crane, and need have only the dimensions required for the proper construction and support of the building itself.

POWER TRANSMISSION.

For the transmission of power from a fixed motor to a traveling or other movable crane, either cotton or wire rope may be employed, according to the conditions of the case.

Where wire rope is employed, rubber-lined driving and guide wheels, of large diameter, and having deep flanges to insure the proper delivery of the rope to the wheel, are required.

Fig. 38 is a cross-section of the rim of a wheel for wire rope, showing the rubber lining contained in a dove-tailed recess at the bottom of the groove. The diameter of driving wheels of this kind should be at least 4 feet, and of the guiding wheels not less than 3 feet. Fig. 39 represents the rim of a wheel for cotton rope, the groove in which is simply turned and polished, the diameter of the wheel being about three feet.

FIG. 38.

FIG. 39.

Wire ropes, where employed, are used with velocities varying from 1,000 to 2,000 feet per minute, according to requirements; cotton rope usually at a velocity of about 5,000 feet per minute. Both kinds of rope have their advantages under certain conditions, but it is preferable in most cases to use cotton rope at high velocity. In England this has been done for many years, but usually under a system of construction by which the power is taken from the rope by pressing small sheaves against it while in motion, and thus imparting a greater or less velocity to the wheels in proportion to the pressure with which they are forced against the rope. As employed in the Weston Cranes, on the contrary, the rope is usually in permanent contact with the driving wheel, so that the latter moves constantly with a circumferential velocity equal to that of the rope, and the power thus transmitted is utilized in the mechanism in the various modes explained under the heads of the several types of cranes. Thus used, the

cotton rope is much more durable and reliable than when employed as in the English cranes referred to; and experience justifies the statement that, under most conditions, a cotton rope thus used is in every way better, more durable, and more satisfactory than wire rope for the transmission of power to cranes.

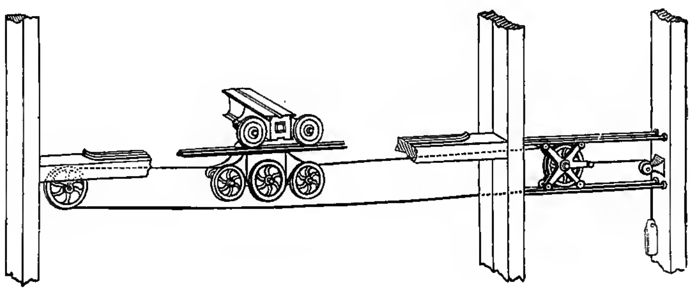


FIG. 40.—Transmission of Power.

Fig. 40 represents the usual method of transmitting power to a Weston traveling crane. Referring to the cut, it will be seen that there are three rope wheels attached to the end of the bridge, the two outer ones being guide wheels, over which the rope is deflected to the driving wheel in the center, the shaft of which latter communicates motion to the mechanism on the bridge. At the left hand is the rope-driving wheel, and at the opposite end an idler over which the rope returns and passes to the crane. This idler is mounted in a frame moving between guides, and strained by a suitable weight so as to give the requisite amount of tension on the driving rope, and to automatically compensate for the stretch of the rope. The same arrangement suffices both for wire and cotton ropes, and with slight modifications is employed also for the transmission of power to walking, jib, and other power cranes.

Where possible, it is always best that the slack side of the driving rope should be below; and where its length is great it may be supported at intervals upon suitable guide sheaves so as to prevent undue deflection.

TAKE-UPS.

In connection with the wire-rope system of bridge propulsion previously described, it is found desirable to employ some means for automatically taking up the slack in the fixed cables resulting from their gradual stretching.

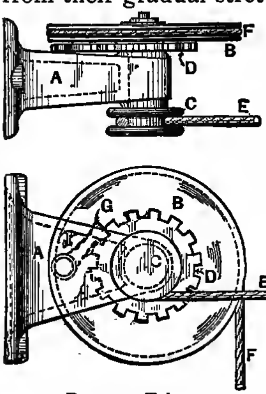


FIG. 41.—Take-up.

For this purpose the "take-up" illustrated in Fig. 41, is employed, consisting of the bracket A securely attached to a wall or post at the end of the longitudinal tracks, and carrying at its outer end a short shaft, attached to one end of which is the small sheave C, and to the other end the larger sheave B. On one side of the latter is formed the ratchet wheel D, and engaging with this is the pawl G, pivoted to the bracket A. E is the fixed cable for squaring and propelling the bridge of the crane, and F is a similar rope wound upon the sheave B, and having suspended from it a suitable weight.

Whenever the fixed cable E has stretched appreciably in service, the slack resulting therefrom is taken up by the action of the weight suspended from the rope F, which, acting through the sheave B and its shaft, causes the sheave C to revolve, thus winding upon the latter a portion of the fixed cable E. This action will take place in each pair of take-ups at a time when the bridge is moving away from them, and when, consequently, the portion of the cable between them and the bridge is relaxed. It will occur automatically whenever there is sufficient slack to permit the ratchet wheel D to be moved one tooth forward. In this way the fixed cables are maintained permanently at a proper tension to effectively perform their work.

HOOKS.

A small but important element of the suspending apparatus of a crane is the hook which terminates it, and by which the hoisting mechanism is attached to or connected with the load to be lifted.

In 1875 all of the various patents relating to the Weston Differential Pulley Block passed into their present ownership, and in organizing for the manufacture of the blocks, it was found that previous practice in the construction of the hooks had been very loose and variable. To determine the correct proportions of hooks the author undertook a careful study of the subject, which led ultimately to long investigation and numerous experimental tests for the purpose of determining the best shapes and dimensions of the several parts of the hook, in order to obtain approximately uniform strength throughout, and to utilize the iron, of which the hook was formed, in the most advantageous and economical manner.

The investigation thus commenced showed that the strains developed in hooks are of an exceedingly complex character, and the determination of the correct proportions of the several parts was only reached, after much study and discussion, by means of mathematical calculations of much intricacy and based upon the results of numerous experiments. The investigation was commenced and conducted by the writer, assisted by the late Mr. Robert Briggs, C. E., and by Mr. T. W. Capen, in addition to which assistance in the mathematical inquiry was obtained from Professor Lanza, of the Massachusetts Institute of Technology. The experimental tests were partly conducted by Professor Thurston, at the Stevens Institute of Technology, Hoboken, N. J., and partly in the works of The Yale & Towne Manufacturing Co. These facts are mentioned to indicate the exhaustive manner in which the inquiry was conducted. It is believed that the investigation of the subject was more thorough than any other that has ever been made, and that the results are proportionately reliable.

Without undertaking here to narrate the intermediate steps of the investigation, we will simply give the final results in the form of the working formulæ.

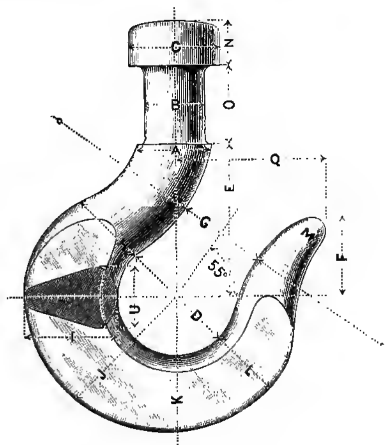


FIG. 42.—Standard Hook.

Fig. 42 represents, to a scale of one-sixth natural size, a 5-ton hook of the dimensions and shape determined by the following formulæ, which give the dimensions of the several parts of hooks of capacities from 250 pounds (or one-eighth of a ton) up to 20,000 pounds (or 10 tons). For hooks of larger sizes the formulæ become slightly different, the general proportions, however, remaining the same.

For economy of manufacture each size of hook is made from some regular commercial size of round iron. The basis, or initial point, in each case is, therefore, the size of iron of which the hook is to be made, which is indicated by the dimension A in the diagram. The dimension D is arbitrarily assumed. The other dimensions, as given by the formulæ, are those which, while preserving a proper bearing-face on the interior of the hook for the ropes or chains which may be passed through it, give the greatest resistance to spreading and to ultimate rupture, which the amount of material in the original bar admits of. The symbol $\triangle$ is used

in the formulæ to indicate the *nominal capacity* of the hook in tons of 2,000 pounds. The formulæ which determine the lines of the other parts of the hooks of the several sizes are as follows, the measurements being all expressed in inches :—

$D = .5\,\triangle + 1.25$	$G = .75\,D$
$E = .64\,\triangle + 1.60$	$O = .363\,\triangle + .66$
$F = .33\,\triangle + .85$	$Q = .64\,\triangle + 1.60$
$H = 1.08A$	$L = 1.05A$
$I = 1.33A$	$M = .50A$
$J = 1.20A$	$N = .85B - .16$
$K = 1.13A$	$U = .866A$

EXAMPLE.—To find the dimension D for a 2-ton hook. The formula is:—

$$D = .5\,\triangle + 1.25$$

and as $\triangle = 2$ the dimension D by the formula is found to be $2\frac{1}{4}$ inches.

The dimensions A are necessarily based upon the ordinary merchant sizes of round iron. The sizes which it has been found best to select are the following:—

Capacity of Hook	$\frac{1}{8}$,	$\frac{1}{4}$,	$\frac{1}{2}$,	1,	$1\frac{1}{2}$,	2,	3,	4,	5,	6,	8,	10	tons.
Dimension A...	$\frac{5}{8}$,	$\frac{11}{16}$,	$\frac{3}{4}$,	$1\frac{1}{16}$,	$1\frac{1}{4}$,	$1\frac{3}{8}$,	$1\frac{3}{4}$,	2,	$2\frac{1}{4}$,	$2\frac{1}{2}$,	$2\frac{7}{8}$,	$3\frac{1}{4}$	inches.

The formulæ which give the sections of the hook at the several points are all expressed in terms of A and can therefore be readily ascertained by reference to the foregoing scale.

EXAMPLE.—To find the dimension I in a 2-ton hook. The formula is $I = 1.33A$, and for a 2-ton hook $A = 1\frac{3}{8}$ inch. Therefore I, in a 2-ton hook, is found to be $1\frac{13}{16}$ inch.

Experiment has shown that hooks made according to the above formulæ will give way first by opening of the jaw, which, however, will not occur except with a load much in excess of the nominal capacity of the hook. This yielding of the hook when overloaded becomes a source of safety, as it constitutes a signal of danger which cannot easily be overlooked, and which must proceed to a considerable length before rupture will occur and the load be dropped. A comparison of these hooks with most of those in ordinary use will show that the latter are, as a rule, badly proportioned, and frequently dangerously weak.

BLOCKS AND BUSHINGS.

In the smaller sizes of Weston Cranes the same form of blocks is used as in the Weston Differential Pulley Blocks, as illustrated in Part IV.

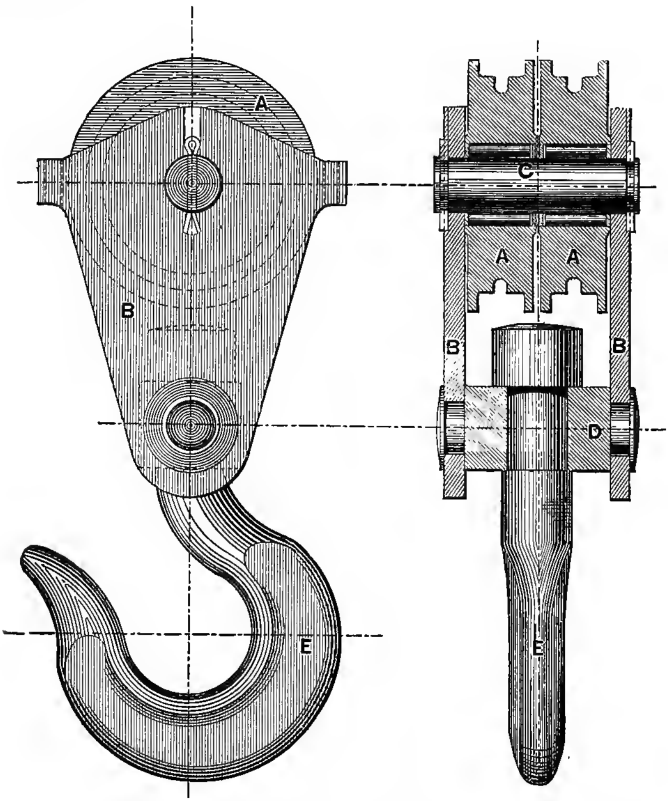


FIG. 43.—Crane Block and Hook.

In the larger sizes the construction of block employed is that illustrated in Fig. 43, in which AA are the chain sheaves, BB

the wrought iron sides or cheek plates, C the pin, D the cross-head, and E the hook. The sheaves AA are properly grooved to receive the chain. The cross-head D is pivoted in the plates BB, and the hook E turns freely within it, so that a compound motion is obtained which permits the hook to be turned in any desired position. Heavy cast iron sides are sometimes bolted to the cheek plates to give additional weight to the block to assist in overhauling the chains when no other load is on them.

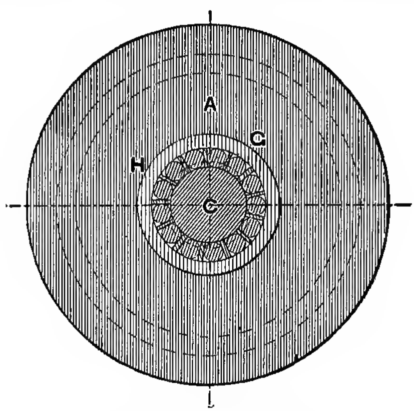


FIG. 44.—Anti-friction Bushing.

Fig. 44 represents one of the sheaves A removed from the block, and shows the construction of anti-friction roller bushing which is employed in all of the larger Weston Cranes to diminish the friction of the sheaves, both in the running block and in the trolley. Referring to the cut, C is the pin upon which the sheave A revolves, and GGG are a series of steel rollers lying between the pin and the sheave. H is a brass cage, composed of an annular rim at each end, with radial bars uniting the two rims and acting as separators between each pair of the steel rollers. Each roller is thus separated from its two neighbors by two of these bars, and is confined endwise between the two annular rims of the cage H. The entire cage revolves with the rollers, but at a speed equal to the circumferential velocity of the rollers, and therefore much slower than that of the sheave A.

Long experience has demonstrated that this form of anti-friction bushing, while very simple, is exceedingly durable and efficient. It requires little care or attention, and performs satisfactorily under the most trying conditions.

These bushings are also used in the wheels of trolleys where the limitations of head-room require the latter to be of small diameter.

PILLAR CRANE FOUNDATIONS.

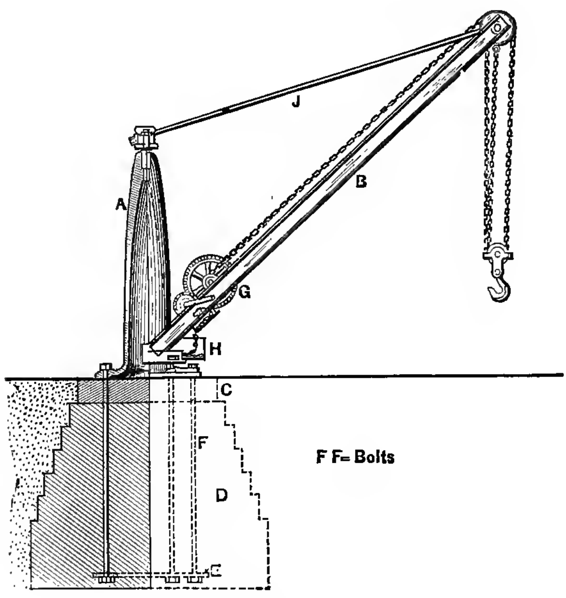


Fig. 45.— Pillar Crane and Foundation.

Fig. 45 is a half sectional view of a Pillar Crane, showing the construction of its foundation.

In this case the crane is entirely supported from below, and the masonry which forms the foundation must have sufficient stability to resist the overturning tendency caused by the load hanging from the outer end of the boom. Where the surrounding ground is sufficiently firm the proportions of this foundation are about as represented in the figure. On filled ground, piling or a timber platform beneath the masonry, or both, may be necessary. These questions can only be properly determined by a consideration of the fact in each case.

Referring to the cut, A is the column of Crane, and B the boom carrying the upper block and revolving around the fixed mast or column A. D is the masonry foundation, E a heavy iron plate or ring embedded in the masonry near its bottom, FF foundation bolts passing through this ring and through the base of the pillar A, thus securely fastening the latter to the foundation. The foundation D may consist of ordinary rubble masonry, covered with a cap stone C, the upper surface of which should be dressed smooth to receive the base of the pillar A. After the completion of the foundation the ground surrounding it should be refilled and thoroughly packed by ramming or puddling, so as to assist the foundation in resisting the strains caused by the crane.

NOTICE

AS TO RIGHTS SECURED BV PATENT.

The numerous inventions and improvements embodied in the various cranes illustrated and described in this book have been patented from time to time as they have been invented, so that all of the important mechanism of the cranes, both in its general features and in detail, is covered by patents belonging to The Yale & Towne Manufacturing Co., which, therefore, has the sole right to make and sell cranes embodying these patented features.

A list of the Company's patents already issued relating to cranes is given on page 103, to which attention is particularly called, but for convenience we give below, in a condensed form, the substance of some of the points which are claimed in these patents and covered thereby. This condensation is given merely for the convenience of readers and without prejudice in any manner to any rights of the company.

CLAIMS OF PATENTS—CONDENSED.

First—The system of propelling the bridge of a crane by means of a cable or cables whereby the crane is pulled in either direction desired.

Second—The use of fixed or movable cables in connection with the bridge of a traveling crane, whereby the bridge, when moved, is compelled by the cables to travel in a direction parallel to its longitudinal tracks.

Third—The combination in a crane of cables, grip wheels, and a driving shaft provided with suitable driving and reversing mechanism, so that the grip wheels may be rotated to drive the crane in either direction as desired.

Fourth—The use, in a crane, of two grip wheels rigidly con-

nected with a common shaft, and two independent cables, one of which cables is led into engagement with its grip wheel in a direction contrary to that of the other, so that while both the wheels are rotated in one direction, the cables will be strained or pulled from contrary directions, thus causing the bridge to travel either way as desired.

Fifth—An endless hoisting chain operated by or used in connection with two independent chain wheels or drums.

Sixth—An endless hoisting chain in connection with two independent chain wheels and intermediate gearing, whereby one side of the chain may be paid out and the other pulled in simultaneously and at equal speeds, in order to cause traverse of the trolley.

Seventh—Constructing the hoisting gear of a crane in such manner that the movement of the trolley in either direction is effected by the same mechanism as employed to effect hoisting and lowering, thus dispensing with the necessity of additional gearing for this purpose.

Eighth—The combination in the mechanism of a power crane of a continuously rotating shaft and two other independent shafts, either one or both of which can be caused, simultaneously or independently, to rotate in the same direction with, or in a direction opposite to, the continuously rotating shaft, so that, while the driving wheel of the crane rotates continuously in one direction, power may be taken off from it for hoisting or lowering, and for traversing the crane on its tracks or the trolley on the bridge, as desired.

Ninth—The combination, with any appropriate friction clutch, of a toggle joint lever or levers, and a sliding collar for actuating the toggle joint, the construction being such that the end thrust of the clutch is absorbed within the shaft itself, and all collar friction thereby avoided.

Tenth—In a traveling crane the location of the operating mechanism at one end of and beneath the bridge, the several chains and ropes being suitably guided thereto from above, so that the bridge may be placed as close as possible to the roof or ceiling and head-room thereby economized.

Eleventh—A crane trolley with a central aperture through which passes the bridge or girder on which the trolley travels, so that the trolley and its attached mechanism entirely surround the girder, thus economizing head-room.

Twelfth—A crane trolley provided with a brake arranged to be actuated from any convenient fixed point on the crane, whereby the operator can lock the trolley in any desired position and so prevent its "creeping" on its tracks during hoisting and lowering.

Thirteenth—A brake for preventing motion of a trolley so constructed as to be automatically released whenever the trolley-moving mechanism is in action, but at all times when hoisting or lowering occurs to automatically hold the trolley stationary, so that it cannot "creep" on its tracks.

Fourteenth—A sustaining brake, to prevent running down of the load, so connected with the operating levers of a power crane that the brake is automatically released whenever the levers are moved to cause hoisting or lowering, but is self-applied at all other times.

Fifteenth—An automatic stop to prevent over-travel of the bridge of a traveling crane at either end of its longitudinal tracks.

Sixteenth—An automatic stop to prevent over-travel of the trolley at either end of the bridge or jib of a crane.

Seventeenth—The use in a crane of two hand-rope wheels, of differential diameters, engaging directly or indirectly with two parts of the same hoisting chain, whereby a variety of speeds is obtained.

Eighteenth—An automatic "take-up" constituting a rigid fastening for the end of a fixed cord or cable when the latter is under strain, but capable, when the strain is relaxed, of automatically taking up the slack arising from stretching.

Nineteenth—A truck for the bridge of a crane consisting of two wheel-brackets, one on each side of the girder or bridge, and a bolt so placed as to properly resist the tensional strain and to securely hold all of the several parts together.

Twentieth—A trolley arranged to travel on the inclined bottom flanges of a beam and having inclined wheel bearings, whereby the axis of each wheel is parallel with the face or bearing of its

track, so that cylindrical wheels, which have a perfect rolling contact, without rubbing or sliding, can be used instead of conical wheels.

Twenty-first—An I-beam, or other flanged tram-rail, provided with a pocket in the upper part of its web, and a bolt and nut, supporting the beam from above, contained within the pocket and not interfering with the wheels of the trolley, so that the latter may be as large as the beam admits of.

Twenty-second—A switch on a suspended tram-rail, one end of which is supported by a pivot and the other by a yoke or head resting upon any number of tracks which it is desired to connect with the switch.

LIST OF PATENTS

[ISSUED BY THE UNITED STATES]

RELATING TO

DEVICES ILLUSTRATED AND DESCRIBED IN THIS BOOK.

No. 67,470 (Reissue), July 9, 1872.
No. 75,227, March 3, 1868.
No. 98,000, December 14, 1869.
No. 119,981, October 17, 1871.
No. 123,342, February 6, 1872.
No. 126,391, May 7, 1872.
No. 127,689, June 11, 1872.
No. 129,914, July 30, 1872.
No. 134,337, December 24, 1872.
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No. 134,958, January 14, 1873.
No. 155,210, September 22, 1874.
No. 155,779, October 6, 1874.
No. 157,660, December 8, 1874.
No. 157,661, December 8, 1874.
No. 157,662, December 8, 1874.
No. 185,060, December 5, 1876.
No. 187,745, February 27, 1877.
No. 194,019, August 7, 1877.
No. 198,718, December 25, 1877.
No. 212,337, February 18, 1879.
No. 212,338, February 18, 1879.
No. 212,339, February 18, 1879.
No. 216,298, June 10, 1879.
No. 217,030, July 1, 1879.
No. 217,031, July 1, 1879.
No. 217,032, July 1, 1879.
No. 229,092, June 22, 1880.
No. 237,675, February 15, 1881.
No. 239,408, March 29, 1881.
No. 241,764, May 17, 1881.
No. 242,271, May 31, 1881.
No. 255,827, April 4, 1882.
No. 263,479, August 29, 1882.
No. 267,149, November 7, 1882.
No. 270,279, January 9, 1883.
No. 270,386, January 9, 1883.
No. 271,311, January 30, 1883.
No. 272,608, February 10, 1883.
No. 273,462, March 6, 1883.
No. 275,465, April 10, 1883.
No. 278,774, June 5, 1883.
No. 278,775, June 5, 1883.
No. 279,704, June 19, 1883.
No. 279,765, June 19, 1883.

PART III.

PART III.

INTRODUCTION.

In this part is comprised a series of illustrations of completed cranes, of numerous types, together with sufficient descriptive matter in each case to indicate clearly the general construction and operation of the crane, and the uses to which it is applicable. All descriptions of details, however, are omitted, except suitable references to the pages in Part II, where they are fully illustrated and described.

In preparing the following illustrations of cranes it was a question whether to represent merely the machines themselves, without surroundings, or to include also the accessories by which each of the several types of cranes is ordinarily surrounded. The former would have involved only the reproduction of working drawings; the latter required the preparation of a series of pictures. The plan of pictorial representation was adopted as tending to best present the subject to the general reader, and as more suggestive of the applications and uses of the various types of cranes. The illustration in each case represents merely one of the many uses to which the several types of cranes are applicable. Most of them are drawn from cranes already in use, and with the actual surroundings. The effort has been rather to represent intelligently the appearance of the crane in actual use than to accurately indicate the several details of its construction. The illustrations contained in this Part will, it is hoped, conduce to a better realization of the wide range of uses to which cranes can with advantage and economy be applied.

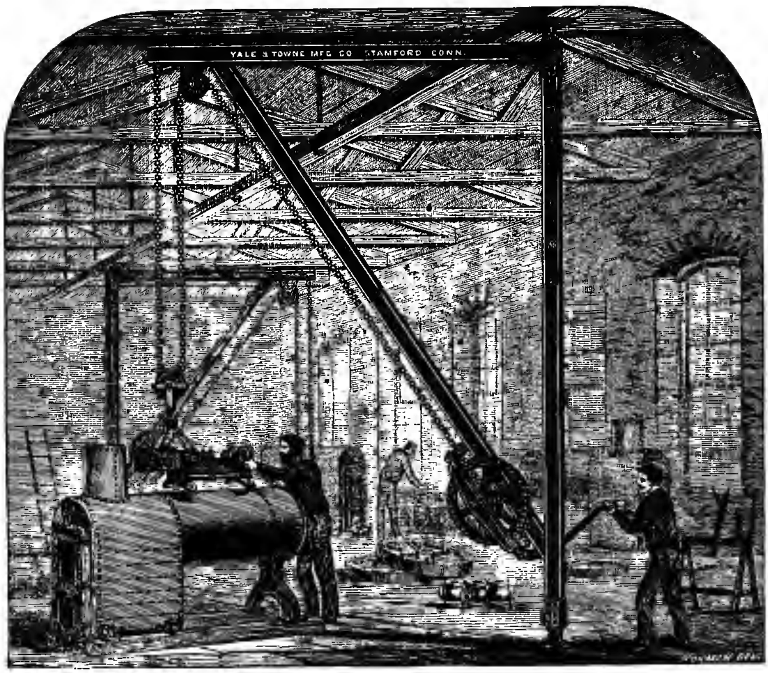


FIG. 46.—Swing Crane, without Trolley.

SWING CRANE.

WITH WINCH.

SINGLE IRON FRAME.—WITHOUT TROLLEY.

Fig. 46 represents the simplest form of rotary crane, in which each member of the frame consists of a single iron beam, and in which the hoisting chain passes over a fixed sheave at outer end of jib, so that the only motions are those of hoisting and lowering, and of rotation. This construction is applicable to cranes of capacities from 100 to 1,000 pounds. For larger sizes it is usually preferable to employ a trolley, as in the crane shown by Fig. 49.

Each member of the frame of this crane consists of a single wrought iron I-beam, suitably connected at their intersections. As the load is not to be moved inward upon the jib the latter is usually supported by a brace, as shown ; although, where desired, a tension rod may be substituted for the brace, as explained on page 82, in which case the appearance of the frame will be substantially like that of the crane illustrated by Fig. 48.

The hoisting gear consists of a pocketed chain wheel, driven by spur gearing, with a frictional safety ratchet upon the primary shaft, so that the load is always self-sustained in any position and cannot run down. Lowering is easily effected by reversing the motion of the crank, but ceases automatically whenever this motion is discontinued.

Rotation is effected by simply pushing or pulling the suspended load, and the construction of the top and bottom pintles upon which the crane revolves is such as to reduce friction to a minimum.

This crane is especially adapted to light work in smith shops, boiler shops, etc., and for use in loading and unloading merchandise in stations, wharves and warehouses.

Estimates will be furnished on receipt of information stating maximum load to be lifted, height from floor to ceiling, and radius of jib.

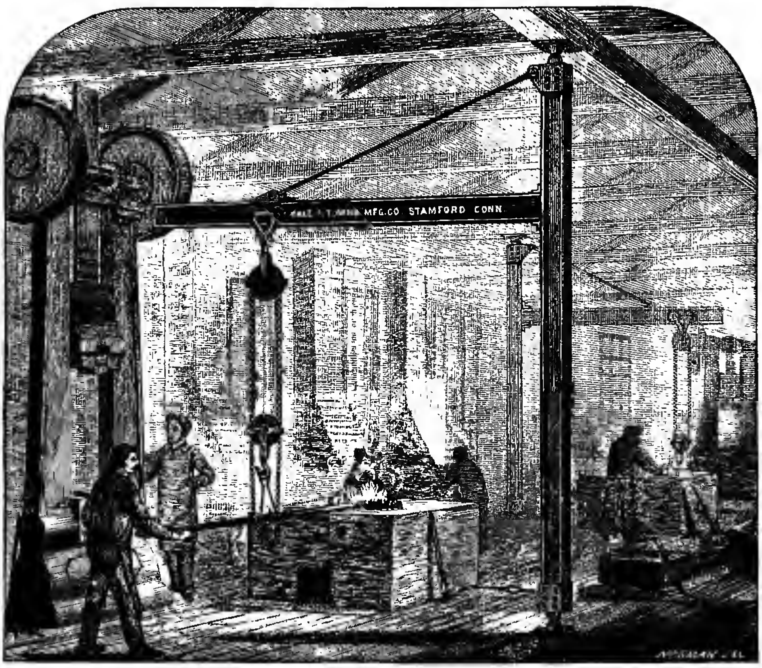


FIG. 47.—Light Jib Crane, with Trolley and Pulley Block.

JIB CRANE.

FOR DIFFERENTIAL PULLEY BLOCK.

SINGLE IRON FRAME.—WITH TROLLEY.

Fig. 47 represents a light Jib Crane in which each member of the frame consists of a single iron I-beam, and in which the hoisting mechanism consists of a differential pulley block suspended from a trolley traveling upon the bottom flange of the jib. This construction is applicable to cranes of capacities from 500 pounds to 2 tons. For larger sizes it is usually preferable to employ the construction shown by Fig. 49.

Each member of the frame consists of a single wrought iron I-beam, suitably connected at their intersections. As a brace under the jib (as shown by Fig. 46) would necessarily restrict the motion of the trolley, the jib is, if possible, always supported by a tension rod above, so that the trolley is free to move inward close to the mast. No gearing of any kind is attached to the crane. Hoisting and lowering are effected by a Weston Differential Pulley Block suspended from the trolley, by means of which the load is always self-sustained at any desired height. Motion of the trolley is effected by pulling or pushing the suspended load, and rotation is effected in like manner.

This Crane is adapted to handling light work in machine shops, forges, boiler-shops, etc., and is particularly convenient for erecting light machine work, or for setting it in lathes and planers.

Estimates will be furnished on receipt of information stating maximum load to be lifted, height from floor to ceiling, and radius of jib.

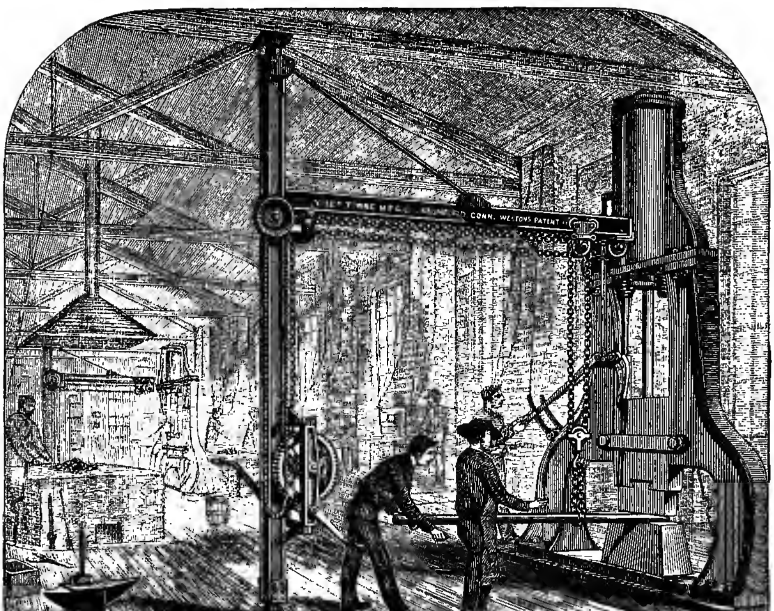


Fig. 48.—Light Jib Crane, with Trolley.

JIB CRANE.

WITH WINCH AND TRAVERSE GEAR.

SINGLE IRON FRAME.—WITH TROLLEY.

Fig. 48 represents a light Jib Crane, similar to that shown by Fig. 47, but provided with mechanism for moving the trolley in and out upon the jib, and other mechanism for hoisting and lowering the load, all permanently attached to the crane. This mode of construction is applicable to cranes of capacities from 500 pounds to 5 tons, although for sizes above 3 tons we prefer the construction shown by Fig. 49.

Each of the several members composing the frame of this crane consists of a single wrought iron I-beam, suitably connected at the intersections. Where the height of room admits of it, the construction shown in the cut is employed, the jib being reinforced by a tension rod above, so that there is no brace below to interfere with the motion of the load upon the jib. When necessary for the jib to be close under the ceiling of the room, a diagonal brace is substituted for the tension rod, as explained on page 82, the appearance of the crane then being similar to that shown by Fig. 46. In this case, however, the trolley cannot move nearer to the mast than the intersection of the brace with the jib. Where it is desirable that the jib should intersect the mast near the top of the latter, and the travel of the trolley on the jib extend close to the mast, resort must be had to the modes of construction shown by Figs. 49 and 50.

The hoisting mechanism consists of a pocketed chain wheel, driven by spur gearing, and having a safety device consisting of an automatic friction ratchet, so that the load is always self-sustained in any position and cannot run down. Lowering is effected by reversing the motion of the cranks, and ceases automatically whenever this motion is discontinued.

Rotation of the crane is effected by pushing or pulling the suspended load, the construction of the top and bottom pintles being such as to reduce friction to a minimum. Motion of the trolley is effected by the independent gear attached to the jib near the mast and operated by the endless hand chain shown in the cut.

This crane is adapted to the same uses as the one previously described and has greater convenience by reason of the addition of the trolley gear. It is particularly serviceable over lathes, planers, etc., and for erecting light machine work, and in forges, boiler shops and similar places.

Estimates will be furnished on receipt of information stating maximum load to be lifted, height from floor to ceiling, effective radius desired, and the mode of bracing preferred. (See page 82).

JIB CRANE.

DOUBLE IRON FRAME.—INDEPENDENT TROLLEY TRAVEL.

Fig. 49 represents a jib crane of medium size, each member of the frame consisting of two parts, separated so as to permit the chain and block to pass between them, so that the load can be moved close in to the mast. The hoisting mechanism is attached to the mast near its foot, and the running block, which carries the load, is suspended from a trolley traveling on the jib and capable of movement in and out by means of independent gearing attached to the jib at its intersection with the mast.

Cranes of this design are built of any desired capacity from 1 ton to 5 tons. For larger sizes the construction shown by Fig. 50 is preferred.

The frame consists of wrought iron channel beams, each of the three members of the frame being composed of two such channel irons. The dimensions are such as to give the accepted factor of safety (see page 83), and the several parts are very securely connected together at their intersections by riveting.

Hoisting is effected through a train of spur gearing, operated by crank in the usual way, and provided with an automatic safety ratchet. Lowering is effected by a separate mechanism consisting of a turned worm wheel and worm, operated by a light hand wheel, as shown in the cut, this mechanism being also available for raising light loads. Thus arranged, the machine is self-sustaining and can be left at any time with the load in suspension without danger of the load running down or the handles flying back. The construction gives three changes of speed, and embodies the endless chain system described at page 67, which insures an even distribution of wear over the entire length of chain.

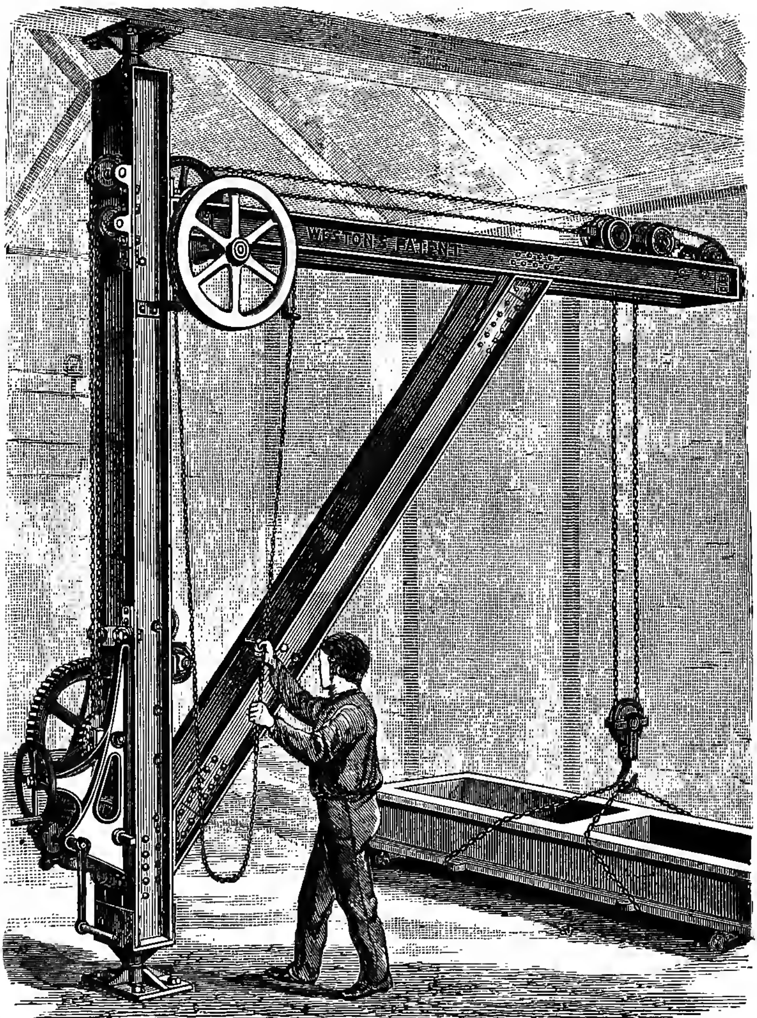


Fig. 49.—Jib Crane, with Separate Trolley Gear.

Rotation is easily effected by pushing or pulling the suspended load, the pintles in top and bottom bearings being of steel and turning in bronze boxes. Motion of the trolley on the jib, in either direction, is effected by gearing operated from below by an endless hand chain, as shown in the cut. The self-sustaining construction of the hoisting gear holds the load suspended at any height while the trolley is moved in and out on the jib.

Cranes of this type are adapted for use in machine shops, for handling and erecting work, in boiler shops, foundries, forges, rolling mills, etc.

Estimates will be furnished on receipt of information stating maximum load to be lifted, height from floor to ceiling, effective radius required, and mode of bracing preferred. (See page 82).

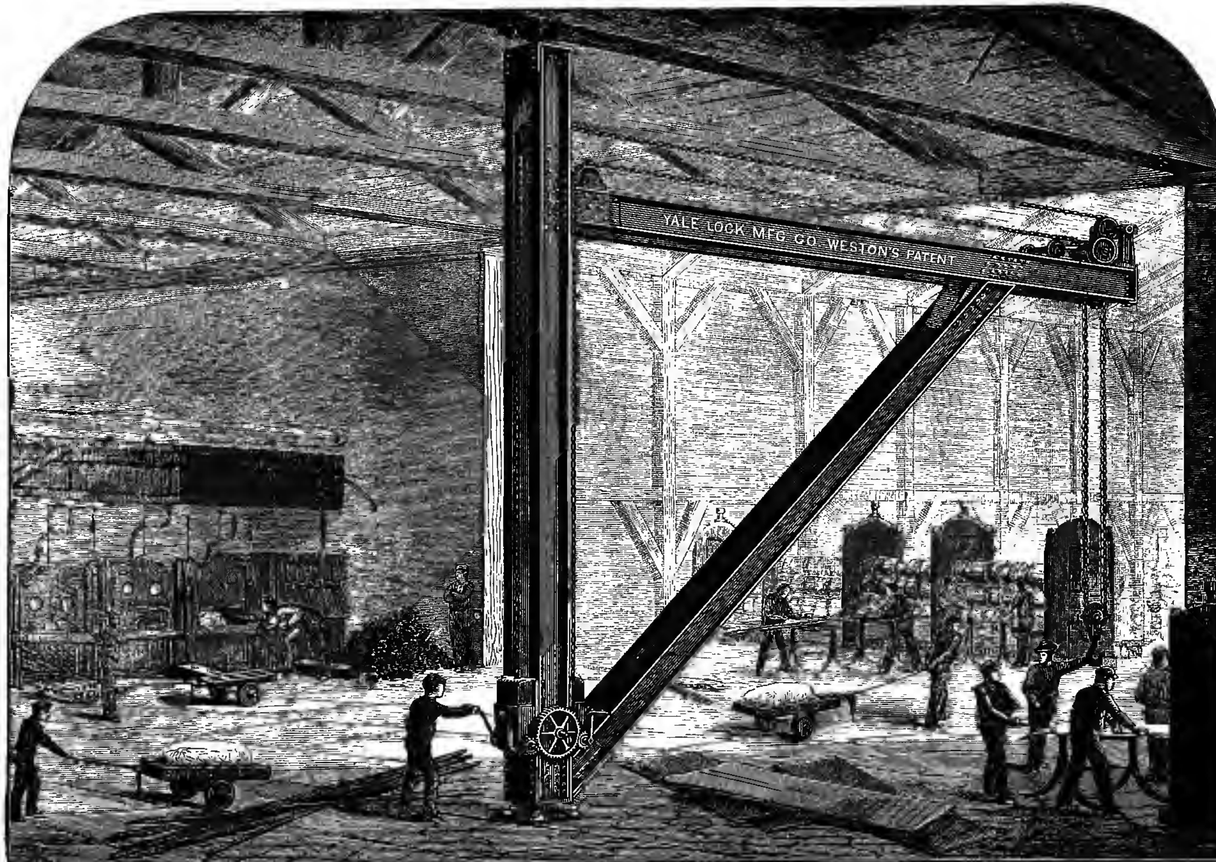


FIG. 50.—Heavy Jib Crane, with Combined Gear.

JIB CRANE.

DOUBLE IRON FRAME.—COMBINED HOIST AND TROLLEY TRAVEL.

Fig. 50 represents a heavy Jib Crane, with wrought iron frame, each member of which is double, so as to permit the block and chain to pass between the two sides of the brace. The load is carried by a running block suspended from a trolley traveling in and out upon the jib, and all of the operating mechanism is attached to the mast near its foot. Cranes of this construction are built with capacities of from 3 tons to 12 tons for operation by hand, and of any desired capacity for operation by power.

The frame consists usually of wrought iron channel beams, each of the three members of the frame being composed of two such channel irons. The main chain passes downward from the trolley between the two irons forming the jib, so that the trolley may be moved close in against the mast. Where the load to be carried, or the dimensions required are such that channel irons are not available, resort is had to plate girders, similar to those used for the bridges of large traveling cranes, as explained on page 83. The dimensions of the several members of the crane are such as to give the accepted factor of safety (see page 83) and the parts are firmly united at their intersections by gusset plates and riveting.

The operating mechanism of this crane is wholly contained within the two housings at the foot of the mast. It consists of worm wheels, driven by turned steel worms running in oil, and provided with automatic friction ratchets which hold the load always suspended, so that it is self-sustained and cannot run down or cause flying back of the handles. The same mechanism is utilized for hoisting and lowering, and for causing travel of the trolley, its mode of action being fully described on page 65, to which

reference is made for a description of the method of hoisting and lowering, and of moving the trolley. As there explained, either crank may be used for hoisting or for lowering. If both are turned simultaneously in the same direction the speed will be doubled, and many men can conveniently apply their strength. By placing the crank upon the center shaft, which carries the large gear wheel, a rapid motion is obtained for lowering, or for raising the empty block. By engaging both pinions with the large center wheel, which is easily and quickly done by two levers not shown in the cut, and then applying the crank to any of the shafts, the trolley is caused to travel in either direction desired, the load remaining suspended at a uniform height. By this mode of operating the trolley the chains between it and the block do not render over their sheaves when the trolley moves, as is the case when an independant trolley mechanism is employed, thus avoiding all needless friction and wear of the hoisting chain and also distributing the wear upon the chain uniformly over its entire length, as explained on page 67, thereby greatly increasing its durability. Lowering is effected by rotating either or both of the cranks backward, and will continue so long as this motion of the cranks is maintained. If it be discontinued, or if the cranks be let go, the load comes to rest and remains automatically suspended. Three changes of speed for hoisting and lowering are obtained, and two for traversing the trolley. The details of this mechanism are described at page 69.

The swinging or rotation of the crane is effected by simply pushing or pulling the suspended load. The top and bottom bearings are bushed with bronze, and the pins or pivots are of steel, turned, with ample provision for lubrication, so that friction is reduced to a minimum. In cranes of large size the chain sheaves in the running block and trolley have anti-friction bushings, as described on page 95.

This type of crane is adapted to heavy work of all kinds, in erecting shops, foundries, forges, rolling mills, stone sheds, etc. When arranged for operation by power its capacity can be indefinitely extended, and proposals for power jib cranes will be furnished on application.

Estimates will be furnished on receipt of information as to maximum load to be lifted, height from floor to roof, effective radius desired, and preference, if any, as to position of brace, also as to whether for operation by hand, power or steam. (See page 82).

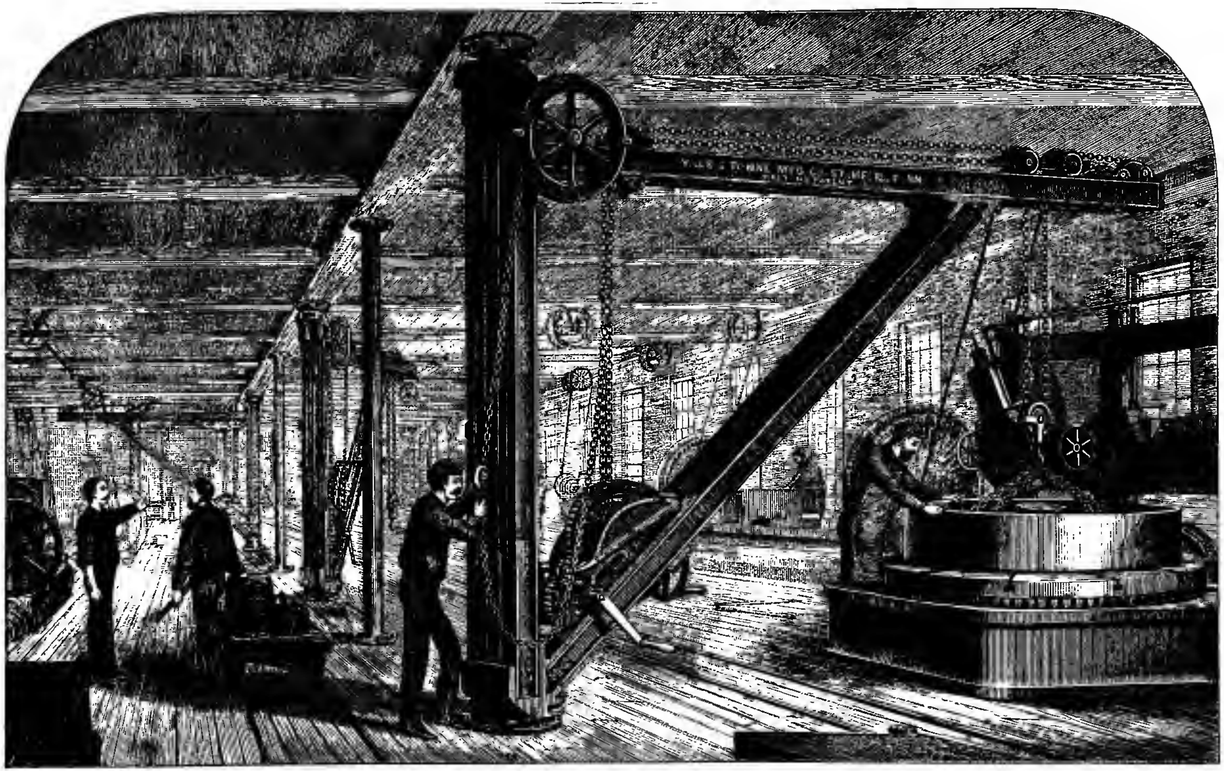


FIG. 51.—Column Crane, or Jib Crane swinging around Fixed Column.

COLUMN CRANE.

DOUBLE IRON FRAME.—TURNING AROUND FIXED SUPPORTING COLUMN.

Fig. 51 represents a jib crane, of essentially the same construction as that described on page 115, but arranged to revolve around a fixed center column within the mast, the column being utilized for supporting the floor above. This type of crane is built of any desired capacity from 1 ton to 10 tons, although for capacities above 5 tons it is best if possible to arrange the cranes independently of the supporting columns.

The mast consists of two wrought iron channel beams, securely fitted to heavy castings at top and bottom, each of which latter contains horizontal rollers, traveling upon turned paths on the center column, the lower or foot casting being provided also with vertical rollers, traveling upon a circular path around the foot of the column. The vertical rollers carry the weight of the crane and load, while the horizontal thrust at top and bottom is received upon the horizontal rollers. Thus arranged the rotation of the crane is as smooth and easy as that of a crane turning upon pintles in the usual way.

All of the other details of this crane being precisely similar to those described on pages 115 to 117, reference is made to that description, which will, therefore, not be repeated here.

This type of crane is designed especially for use in buildings where an upper floor is supported upon columns which cannot be removed, and around which it is therefore desirable that the cranes should rotate. Thus arranged they have all the convenience and applicability of ordinary jib cranes.

Estimates will be furnished on receipt of information as to the maximum load to be lifted, height from floor to ceiling, effective radius desired, and distance from center to center of column, where they are so near as to limit the sweep of the crane. By limiting the latter to less than an entire revolution, the jib may be lengthened so as to extend beyond the adjacent column.

FIG. 52.—Walking Crane, as arranged for operation by Power.

WALKING CRANE.

FOR OPERATION BY POWER OR HAND.

Fig. 52 represents a walking crane operated by power and consisting of a boom, rotating around a fixed column mounted upon an extended truck, which latter travels upon a suitable rail upon the floor. Power is utilized for hoisting and lowering, and for propelling the crane longitudinally upon its track. Cranes of this type are built of any desired capacity from 1 to 10 tons, and for operation either by hand or by power.

The base consists of two wrought iron girders united by riveting and carrying between them the truck wheels which support the crane. Rising from the center of the base is a cast iron column, somewhat similar to that of the pillar crane shown on page 132, and revolving around this is the mast, consisting of two channel irons, united by suitable castings at top and bottom, and containing the rollers by which the mast is supported as it revolves. The boom is also formed of two channel irons, and from its outer end is suspended the running block, the chain from which passes over a sheave at the end of the boom to the hoisting gear attached to the mast near its head, the slack chain falling from this to a receptacle at the foot of the boom.

The mechanism of this crane, when operated by power, is arranged as shown in the engraving. Power is transmitted by a driving rope passing around a wheel on top of the vertical shaft forming the axis of the crane, this shaft thus moving continuously in one direction at a constant speed. By a series of Weston Disc Clutches, controlled by suitable levers within easy reach of the operator, the power is made available for hoisting and lowering, and for propelling the crane in either direction upon its track. Rotation of the crane is effected in the usual way by pushing or pulling the suspended load. The levers are so arranged that the

operator may either walk beside the crane as it moves, or may travel upon it. The crane is supported longitudinally by the extended wheel base of the truck, and transversely by rails bolted to the roof or ceiling, between which travels the horizontal truck or guide frame attached to the head of the mast.

When arranged for operation by hand, the hoisting gear of this crane is similar to that of the pillar crane described on pages 133 and 134, and the longitudinal travel of the crane is effected by a separate crank, operating mechanism attached to the base. The system of clutches employed is explained at page 41.

Cranes of this type are adapted for use in machine shops, for setting work in the various machine tools and for transferring it from one tool to another, and also in erecting shops for transferring parts to the place of erection and for setting them in position. For work of this description these cranes are exceedingly convenient and economical.

Estimates will be furnished on receipt of information as to whether to be operated by hand or power, maximum load to be lifted, effective radius desired, length of longitudinal travel and height from floor to ceiling.

ROTARY BRIDGE CRANE.

DOUBLE IRON FRAME.—COMBINED HOIST AND TROLLEY TRAVEL.

Fig. 53 represents a novel form of rotary crane and one which possesses many advantages for certain kinds of work. It consists of a mast and jib, as in an ordinary jib crane, but is provided with a circular overhead track carrying the outer end of the jib, or rotary bridge, so that the latter may easily have a much greater length than the jib of an ordinary jib crane, and so that all diagonal braces are dispensed with and the entire space under the bridge left unobstructed. Cranes of this construction are built of capacities from 3 to 12 tons for operation by hand, and of any desired capacity for operation by power.

The frame consists usually of wrought iron channel beams, the mast and the bridge each being composed of two such channel irons. The operating mechanism, for operation by hand, is contained wholly within the two housings at the foot of the mast, and its construction and action are identical with those of the jib crane described on pages 119 to 121, to which reference is made for further particulars. The same mechanism is utilized for hoisting and lowering at several speeds, and for causing travel of the trolley in either direction upon the bridge. Rotation is effected by simply pushing or pulling the suspended load, except in cranes of large size, which are provided with a power mechanism for this purpose. The construction of the upper bearing of the crane, by which the head of the mast is carried, is such as to avoid any severe lateral strains upon the roof, the weight being carried, at one end of the bridge, by the mast, and at the other by the circular track, which is supported from the ground by suitable posts.

This type of crane affords all the conveniences of the ordinary jib crane, while avoiding the limitation in the vertical movements of the load imposed by the diagonal braces of the latter.

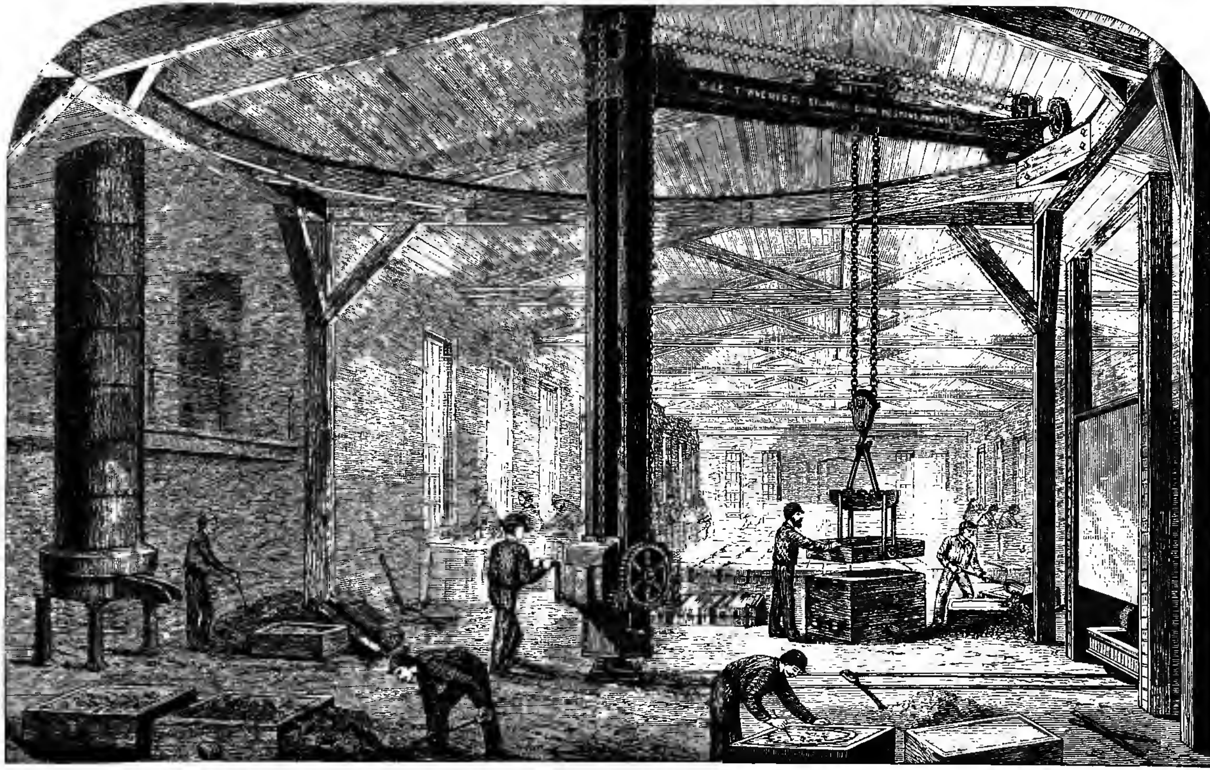


FIG. 53.—Rotary Bridge Crane.

It also avoids the severe lateral strains upon the building which result from the use of jib cranes, and thus dispenses with the heavy walls or bracing necessary, where jib cranes are employed, to afford the proper support of the upper end of the mast of such cranes. The posts supporting the circular track can easily be so placed as to cause little if any obstruction upon the floor, or, if the roof be stiff enough, the track may be hung directly from it without resorting to special posts. The bridge, being supported at both ends, can conveniently have much greater span than the jib of a jib crane, the outer end of which is necessarily overhung. With rotary bridge cranes of ordinary capacity a span of 50 feet is entirely feasible, and in this way the crane can be made to cover a circular floor 100 feet in diameter.

Cranes of this type are adapted to heavy and light work of all kinds, especially in foundries, erecting shops, stone sheds, etc. When arranged for operation by power their capacity can be indefinitely extended. They are particularly applicable to existing buildings the shape of which does not adapt them to the application of traveling cranes, and in which the construction does not adequately provide for the strains which would result from the use of jib cranes.

Estimates will be furnished on receipt of information as to whether to be operated by hand, power or steam, the maximum load to be lifted, height from floor to roof, effective radius desired, and such particulars concerning the building as will give a clear understanding of the situation.

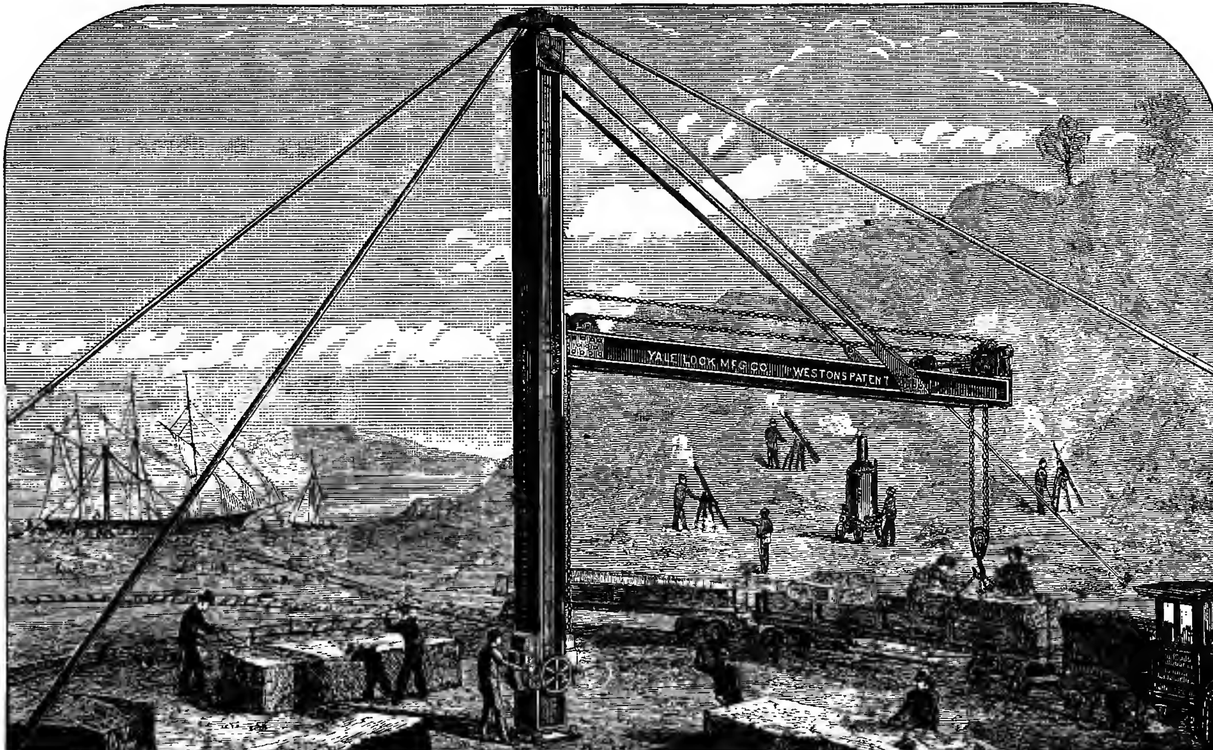


FIG. 54.—Derrick Crane, for outdoor use.

DERRICK CRANE.

IRON FRAME.—WITH TROLLEY MOTION.

Fig. 54 represents a heavy derrick crane for outdoor use, the construction being substantially identical with that of the jib crane illustrated by Fig. 50, except that the head of the mast is supported by guy rods, instead of by attachment to a roof or ceiling. This style of crane is built of capacities from 5 to 20 tons, and of any desired dimensions of mast and jib.

The description on pages 119 to 121 of the jib crane therewith illustrated will apply to this crane also, all of their several parts being identical, except that in this case the mast is extended somewhat above the jib, and the upper bearing, in which the mast revolves, is supported laterally by guy ropes, or rods, attached at their lower ends to suitable anchors in the ground, or to adjacent buildings. The motions of hoisting and lowering, and travel of the trolley on the jib, are all effected by means of the mechanism at the foot of the mast. By pushing or pulling the suspended load rotation of the crane is effected as easily as in the case of the ordinary jib crane.

This crane is adapted for use in freight yards, quarries, and on wharves, and can be substituted for the pillar crane shown on page 132, where the guy rods are not objectionable, or where there is difficulty in obtaining the foundation needed to support a pillar crane. It can also be arranged for operation by power, or by direct steam.

Estimates will be furnished on receipt of information stating whether to be operated by hand, power or steam, maximum load to be lifted, effective radius of jib required, and particulars as to surrounding buildings, if any, which are available for attachment of guys.

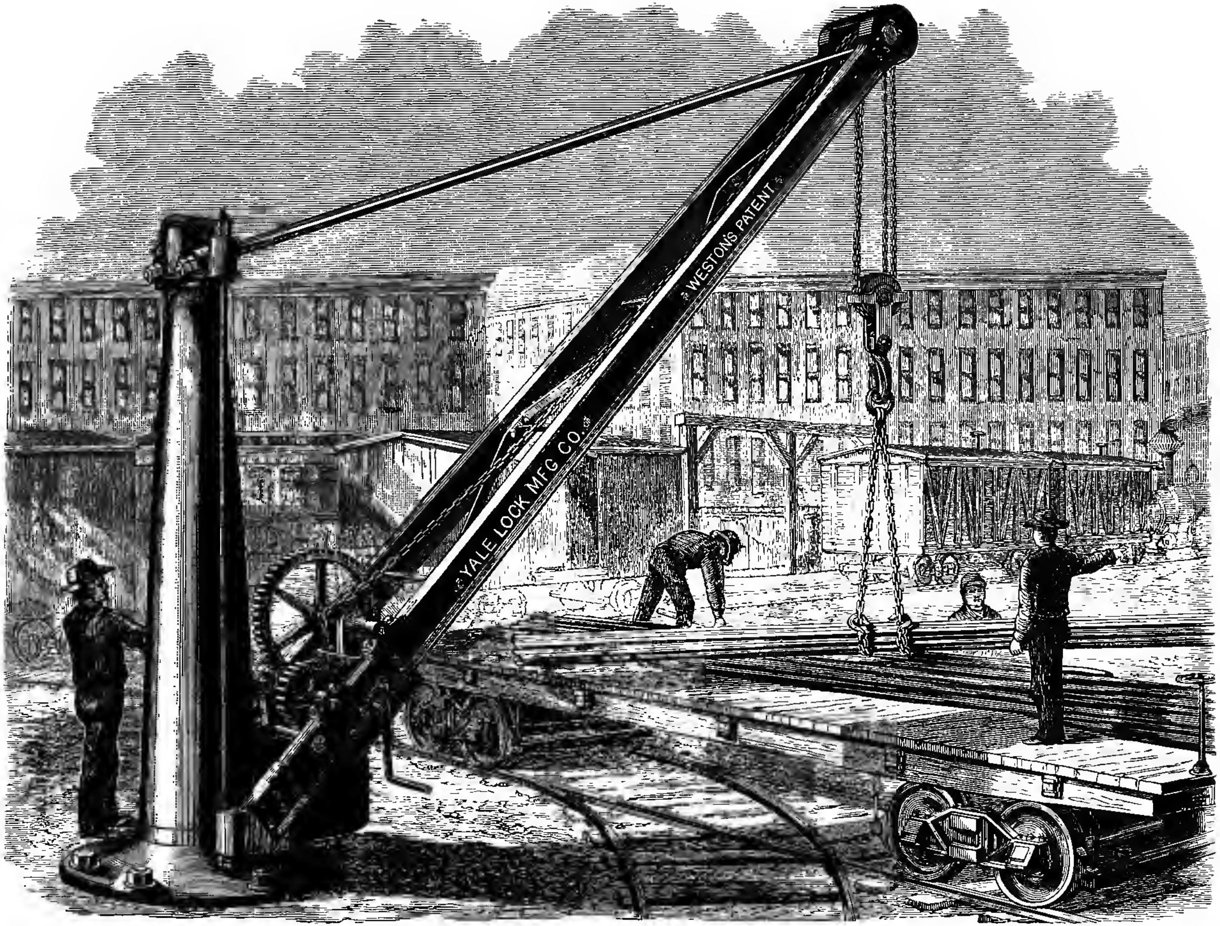


FIG. 55.—Pillar Crane, for operation by Hand.

PILLAR CRANE.

SUPPORTED BY FOUNDATION ONLY.

Fig. 55 represents a pillar crane which is supported entirely by a suitable foundation, of masonry or timber, to which the central pillar or column is securely bolted, the boom being supported by this column and rotating around it. This style of crane is built of any desired capacity from 1 ton upwards, and of any desired radius.

As this crane is supported entirely from below, without any assistance from overhead braces or attachments, it requires a heavy foundation, of sufficient mass and weight to firmly resist the overturning tendency of the load when suspended at the outer end of the boom. The proper construction of this foundation is explained in Part II, pages 97 and 98. As there shown it consists of rubble masonry built on a suitable foundation and covered with a cap stone immediately under the base of the iron column. A heavy foundation plate and holding down bolts are set in the masonry and the latter built around them, the bolts passing through the cap stone and serving to rigidly fasten the column of the crane to the foundation, as shown in the illustration. A drawing of the necessary foundation is furnished to parties ordering cranes of this kind.

The pillar or column of the crane is of cast iron, and of simple but symmetrical design, its form being proportioned to the strains it has to resist. It has a broad base, thus giving it a good footing on the foundation and spreading the holding down bolts well apart. Fixed in the head of the column is a steel pin or pivot upon which rests the cross head or yoke. The latter is bushed with bronze and has proper provision for lubrication, so that the cross-head shall always turn freely on the pin. The boom or strut consists of two wrought iron channel beams, well braced to-

gether and united at the upper end by a head casting carrying the upper chain sheaves over which the chain passes to the running block. The foot of the boom is supported vertically by two suspension rods, hung from the ends of the cross-head, and its upper end or head is held by two guy rods, also extending back to the cross-head. The horizontal thrust at the foot of the boom is transmitted to two turned rollers, placed within the foot casting of the boom and traveling upon a turned path around the base of the column. The weight, both of the boom and load, is entirely carried by the steel pin at the top of the column, and the friction of rotation is thus reduced to a minimum.

The hoisting gear is attached to the boom near the column and rotates with the former. It consists of a train of spur gearing provided with an automatic safety ratchet and with the Weston Disc Brake for lowering, substantially as in the jib crane described on pages 115 to 117, so that the load is always self-sustained and cannot run down, nor the handles recoil on the operator. Lowering is effected by turning the cranks backward, the load descending easily and smoothly so long as this motion is continued, but coming to rest if the backward motion be discontinued or the handles let go. Two changes of speed are provided. Swinging or rotation of the crane is effected by pushing or pulling the suspended load, and the construction is such that the maximum load can be easily swung by one man.

This type of crane is designed for yard use where there is no roof or ceiling to support the top of crane, and where guy rods, as shown by Fig. 54, are objectionable. It is particularly adapted to railroad and wharf use, for loading and unloading heavy work from cars or boats, and is a useful addition to the yard appliances of any large works. They are constructed for operation by hand, by power or by direct steam, according to the requirements of the case.

Estimates will be furnished on receipt of information as to maximum load to be lifted, effective radius desired, and source of motive power, if other than manual.

LOCOMOTIVE CRANE.

SELF-PROPELLING.

Cranes of this type consist of a rotary crane, usually of the pillar variety, as shown by Fig. 55, mounted upon a suitable car or truck, and provided with an independent boiler and engine, the power of which is utilized for hoisting, lowering and rotating the load, and also for propelling the car upon its tracks.

Locomotive cranes are of great convenience in large works of all kinds where the buildings cover much ground and are connected by means of railroad tracks. By means of these tracks the crane can be transferred from one place to another, to suit the requirements of the work, and can be utilized also for transferring heavy loads from one building to another. They are useful also upon freight wharves where, by means of a track laid near the edge of the wharf, they can be utilized for unloading vessels and also for transferring heavy loads from one vessel to another.

The construction of cranes of this type is varied according to the requirements of the work to be done, but they embody in one form or another the same arrangements and details as the other cranes described in this book.

Estimates for locomotive cranes will be submitted upon receipt of information as to the maximum load to be lifted, the effective radius desired, the gauge of track on which the crane should travel, and other particulars as to the nature of the work to be done.

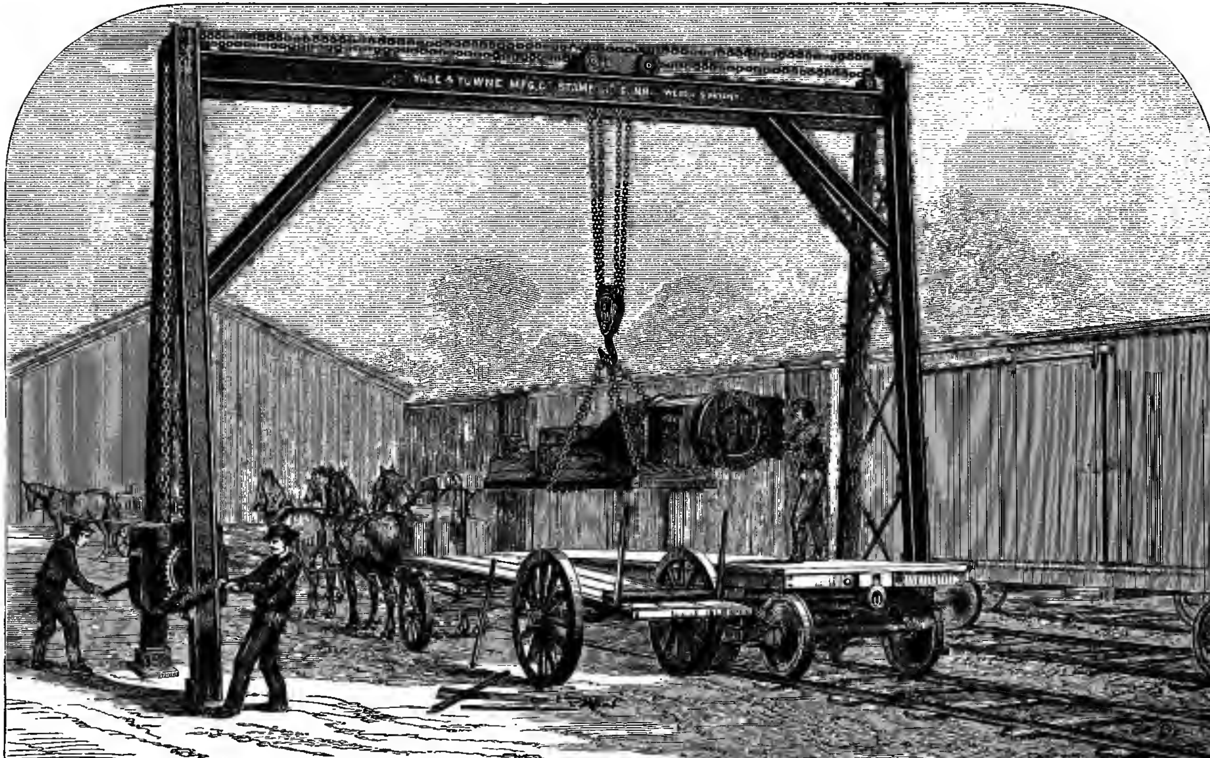


FIG. 56.—Bridge Crane, operated by Hand.

BRIDGE CRANE.

IRON FRAME.—FOR OPERATION BY HAND OR POWER.

Fig. 56 represents a crane for yard use consisting of a stationary bridge, supported at each end by a suitable trestle, and provided with a trolley moving transversely on the bridge. The load is carried by a running block suspended from the trolley, and the mechanism for hoisting and traversing is attached to one of the vertical frames or trestles near its foot. Cranes of this construction are built of capacities of from 2 to 12 tons for operation by hand, and of any desired capacity for operation by power.

Fig. 57 represents another form of bridge crane, in which one end of the bridge is supported by a building and the outer end by a frame or trestle, so that the frame is available for transferring weights into or out of the building. In some cases a crane of this type is placed between two adjoining buildings, its ends being supported by the adjacent walls of each building; while in other cases the bridge of the crane is carried through the doorway of a building, so that the load can be transferred from a truck or car outside of the building to some point within it.

The crane shown by Fig. 56 is arranged for operation by hand, and is built entirely of iron. It is provided with mechanism substantially identical with that of the jib crane described on page 119, to which reference is made for further particulars. The same mechanism is utilized for hoisting and lowering at several speeds, and for causing the trolley to travel upon the bridge.

The crane shown in Fig. 57 is arranged for operation by power, the operating mechanism being located within the building and driven by power taken from the line shafting. The levers for controlling the several motions are placed upon the wall of

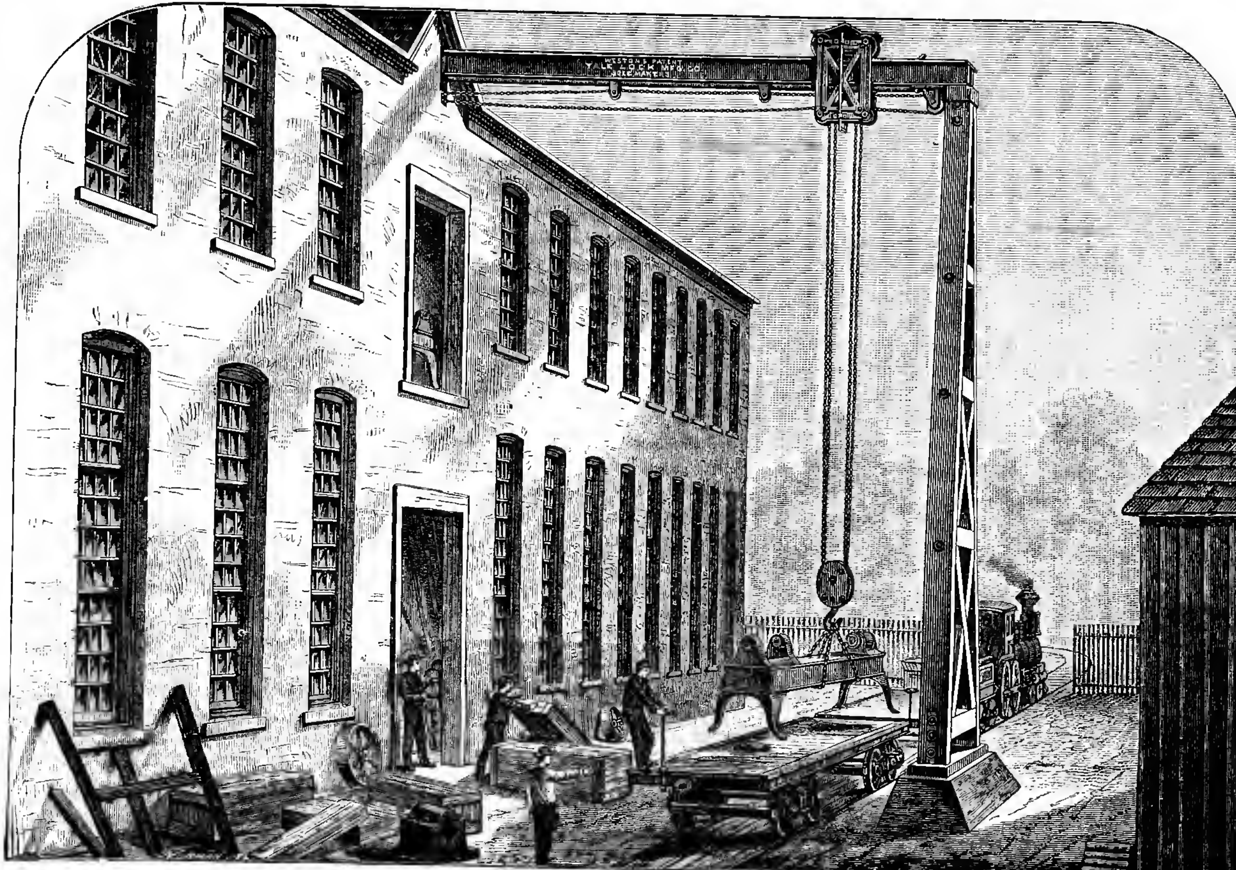


FIG. 57.—Bridge Crane, operated by Power.

the building at any convenient point within, and arranged so that they may be used from either of the several floors. The operating mechanism is substantially identical with that employed in the power traveling cranes described on page 155, the details being more particularly described in Part II, page 73.

Cranes of this type are available for yard uses of all kinds in connection with foundries, machine shops, quarries, etc. They are particularly available for loading and unloading heavy freight from cars, and are an excellent substitute for the pillar crane illustrated by Fig. 55. As compared with the latter they have the advantage of not requiring any foundation except that necessary to resist the direct pressure due to the load. They may be made to span two or more tracks and are thus available for transferring loads from one car to another, or from a car to a truck or platform.

Estimates will be furnished on receipt of information as to whether to be operated by hand or power, the maximum load to be lifted, the height of bridge above ground, the length between supports, and particulars as to mode of supporting the bridge, that is, whether by independent frames or by the walls of buildings.

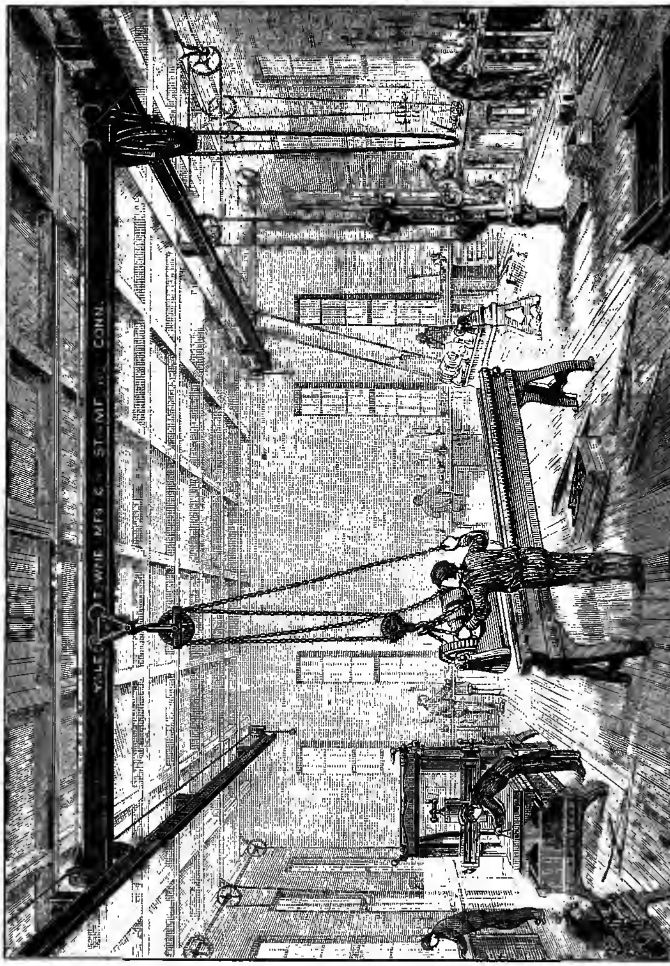


Fig. 58.—Light Hand Traveling Crane.

HAND TRAVELING CRANE.

FOR DIFFERENTIAL PULLEY BLOCK.—LONGITUDINAL TRAVERSE GEAR ONLY.

Fig. 58 represents a light traveling crane, for operation by hand, in which the hoisting mechanism consists of a Weston Differential Pulley Block suspended from the trolley.

The bridge is arranged to travel lengthwise upon the longitudinal tracks, and the trolley to move transversely upon the bridge, so that the entire rectangular space between the tracks is covered by the crane. If desired, several trolleys and blocks can be fitted to the same crane. This style of crane is built of any desired capacity from 1 ton upwards, and of any desired span.

The mechanism attached to the right hand end of the bridge consists substantially of the bridge-traveling apparatus described on pages 58 to 60, Part II. It is operated by a single endless hand rope or chain, reaching from the machine downward towards the floor, by pulling one side of which the bridge is propelled in one direction upon its tracks, while by pulling the opposite side the bridge is propelled in the opposite direction. The Weston fixed cable system of propulsion is employed, and is utilized also to effect the squaring of the bridge with its tracks, as explained on page 54, so that the bridge moves always in parallelism with its tracks, and with a minimum resistance. For light loads and short spans the squaring device is not essential (although it is always conducive to smoother and easier motion), in which case a simple bridge without any squaring device may be used. The latter arrangement, however, cannot be recommended except for very short spans, and in all other cases the crane shown in Fig. 58 is to be preferred.

The construction of the bridge is explained on page 85, the bridge trucks on page 78, and the trolley and the Differential Pulley Blocks in Part IV.

None of the mechanism projects more than a few inches above the top of the bridge, so that the latter may be placed close to the ceiling or roof timbers of the room, thus affording the greatest possible height of hoist. The longitudinal motions of the bridge are effected by pulling the hand rope as above explained, and the transverse motion of the trolley on the bridge by pushing or pulling the suspended load.

This crane is especially adapted to light foundry work, to the erection of light machinery, to the setting of work in lathes, planers, etc., and for use over very heavy machines, such as steam engines, rolling mills, printing presses, etc., for the removal and handling of parts during repairs.

Estimates will be furnished on receipt of information as to maximum load to be lifted, span or length of bridge, height of ceiling, and length of longitudinal travel.

HAND TRAVELING CRANE.

FOR DIFFERENTIAL PULLEY BLOCK.—WITH TRANSVERSE AND LONGITUDINAL TRAVERSE GEAR.

Fig. 59 represents a light Traveling Crane for operation by hand, in which, as in Fig. 58, the hoisting mechanism consists of a Weston Differential Pulley Block suspended from the trolley, but which is provided not only with mechanism for traversing the bridge upon the longitudinal tracks, but also with mechanism for causing travel of the trolley upon the bridge. As shown in the engraving, the Crane is provided with two complete trolleys and blocks, but can of course be furnished with one or more, as desired.

In this, as in the preceding illustration, the bridge is arranged to travel lengthwise, and the trolley (whether one or more) to move transversely upon the bridge, thus covering the entire space embraced between the tracks. Cranes of this type are built of any desired capacity from one ton upwards, and of any desired span.

The mechanism attached to the right hand end of the bridge consists of the bridge-traveling apparatus described on pages 58 to 60. It is operated by a single endless hand rope or chain, extending downward towards the floor, by pulling one side of which the bridge is propelled in one direction upon its tracks, while by pulling it on the opposite side the bridge is propelled in the opposite direction. The Weston fixed-cable system is employed, both for propelling the bridge and for squaring it with its tracks, as explained at page 54. For light loads and short spans the squaring device is not essential, although always conducive to smoother action, in which case a simple bridge, without squaring device, may be used. The latter arrangement, however, is not recommended except for short spans and light loads.

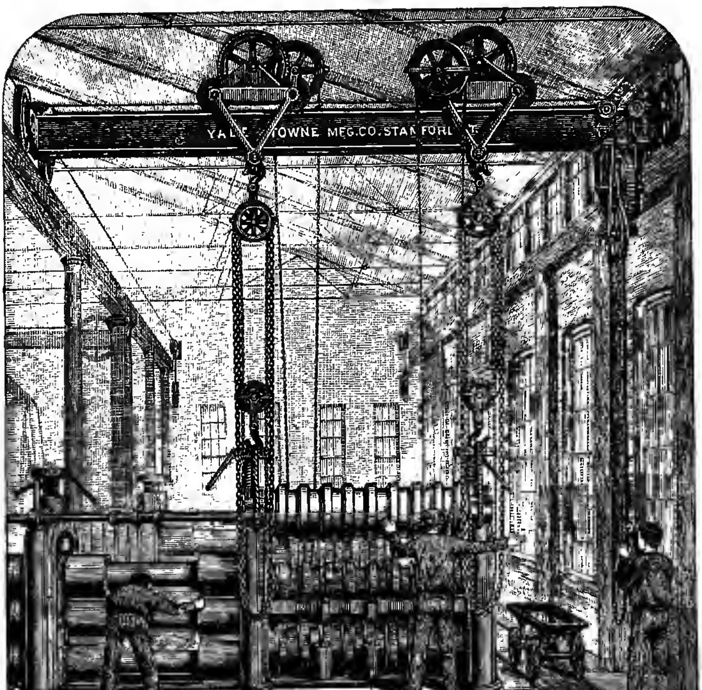


FIG. 59.—Light Hand Traveling Crane.

As illustrated in the engraving the Crane is provided with two independent trolleys, each having a differential pulley block suspended from it. Thus arranged, it is particularly convenient for lifting bulky loads, or for handling the heavy parts of engines or other machinery which require to be removed for repairs or inspection. Each trolley is provided with independent mechanism for causing it to travel upon the bridge, and is controlled by means of a single endless hand chain depending from the trolley, as shown in the engraving.

The construction shown in the engraving is desirable wherever the head-room admits of it. Where absolutely necessary, however, the mechanism can be so arranged as to occupy but little more space above the bridge than in the crane shown by Fig. 58. In this case the general appearance of the trolley is somewhat as represented in Fig. 61. The chief point of difference between this crane and the one illustrated in Fig. 58 consists in the addition of the mechanism for causing travel of the trolley upon the bridge by means of a hand chain operated from the floor below, instead of by pushing or pulling the suspended load.

This crane is adapted to the same range of uses as stated in connection with the crane illustrated by Fig. 58, the addition of traverse gear making it more desirable where heavy loads are to be handled.

Estimates will be furnished on receipt of information as to maximum load to be lifted, span or length of bridge, height of ceiling, and length of longitudinal travel.

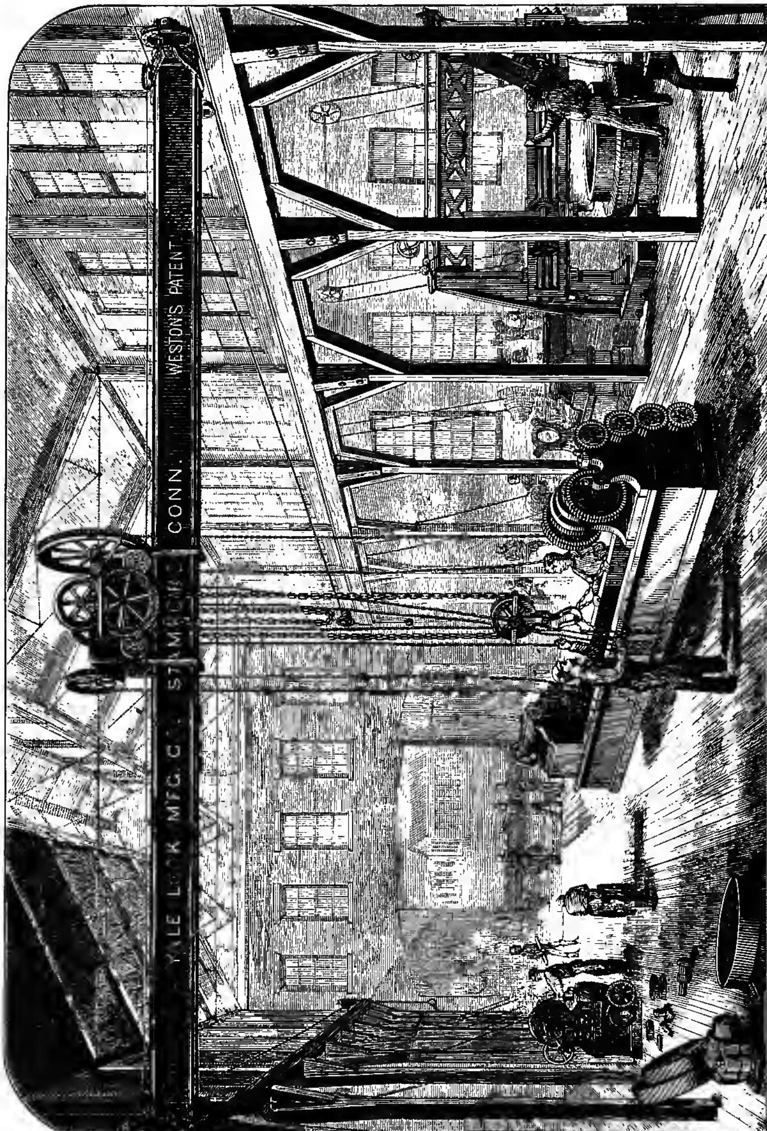


FIG. 60.—Hand Traveling Crane, with Overhead Trolley.

HAND TRAVELING CRANE.

COMBINED TROLLEY (HIGH PATTERN) WITH COMPLETE HOISTING AND TRAVELING GEAR.

The illustration on opposite page represents a complete traveling crane, arranged for operation by hand from the floor below, the operating mechanism being contained entirely within a trolley-crab, placed on top of the bridge and moving transversely upon it. This location of the trolley is to be preferred wherever the head room within the building admits of it. Two or more trolleys may be placed upon the same bridge. The bridge is arranged to travel lengthwise upon the longitudinal tracks, and the trolley to move transversely upon the bridge, so that the entire rectangular space between the tracks is covered by the crane. This design of crane is built of any desired capacity up to 10 tons, and of any span.

The squaring of the bridge, and its motion upon the longitudinal tracks, and also the motion of the trolley upon the bridge, are all effected by the Weston system of fixed cables as explained in Part II, page 61. The crab or housing containing the mechanism travels upon rails on top of the bridge, and is located entirely above the latter, so that the breaking of any of its parts will merely allow them to rest upon the bridge without permitting the load to fall more than a few inches. This disposition of parts is always desirable if the overhead space is sufficient to admit of it, and for this reason the cranes herewith illustrated should be adopted in preference to the one illustrated by Fig. 61, wherever the circumstances of the case make it feasible.

The several operations are effected by four endless hand chains or ropes depending from the crab. Those at the opposite sides of the crab give motion to the bridge and to the trolley, as explained at page 61. Those at the ends of the crab effect

hoisting and lowering, one of them passing over a small wheel for quick speeds, and the other over a larger one for slow speeds, a third speed being obtained by using both simultaneously. The hoisting gear consists of cut steel worms, engaging with cut worm wheels, with provision for thorough lubrication. The main hoisting chain is endless, and passes over pocketed chain wheels by which it is driven, the arrangement of parts being such as to distribute the wear equally throughout the entire length of this chain in a manner somewhat similar to that described on page 67. A safety device, consisting of automatic friction ratchets in combination with the worm shafts, is employed, so that the load is always self-sustained in any position and cannot run down. Lowering is effected by reversing the motion of the hoisting chains. For descriptions of the various details of this crane reference is made to Part II.

This type of crane is adapted to machine shop use, for erecting and setting work, to forges, boiler shops, stone yards and other places where heavy loads are to be handled. Where applicable, it is the most perfect and convenient form of crane for operation by hand.

Estimates will be submitted on receipt of information as to maximum load to be lifted, span or length of bridge, height from floor to ceiling or roof, and length of longitudinal travel.

HAND TRAVELING CRANE.

COMBINED TROLLEY (LOW PATTERN) WITH COMPLETE HOISTING AND TRAVELING GEAR.

The Crane illustrated on next page is of the same general character as that in the preceding illustration, except that the trolley-crab and its operating mechanism are arranged at each side of and below the bridge, the form of the trolley being such as to enable the bridge to be placed close under the roof or ceiling of the room. Two or more trolleys may be placed upon the same bridge. The bridge is arranged to travel lengthwise upon the longitudinal tracks, and the trolley to move transversely upon the bridge, so that the entire rectangular space between the tracks is covered by the crane. This type of crane is built of any desired capacity up to 10 tons and of any span.

The hoisting gear consists of cut steel worms engaging with cut worm wheels, with provision for thorough lubrication. The main hoisting chain is endless and passes over pocketed chain wheels by which it is driven, the arrangement of parts being such as to distribute the wear equally throughout the entire length of this chain.

A safety device, consisting of automatic friction ratchets in combination with the worm shafts, is employed, so that the load is always self-sustained in any position, and cannot run down. Lowering is effected by reversing the motion of the hoisting chains.

The Weston system of fixed cables (see Part II, page 61) is employed to effect the squaring of the bridge with its tracks, and its propulsion upon them, and also to move the trolley transversely upon the bridge. The operating mechanism is contained entirely within the trolley, and its motions are controlled by four endless hand ropes or chains depending from it, two of which

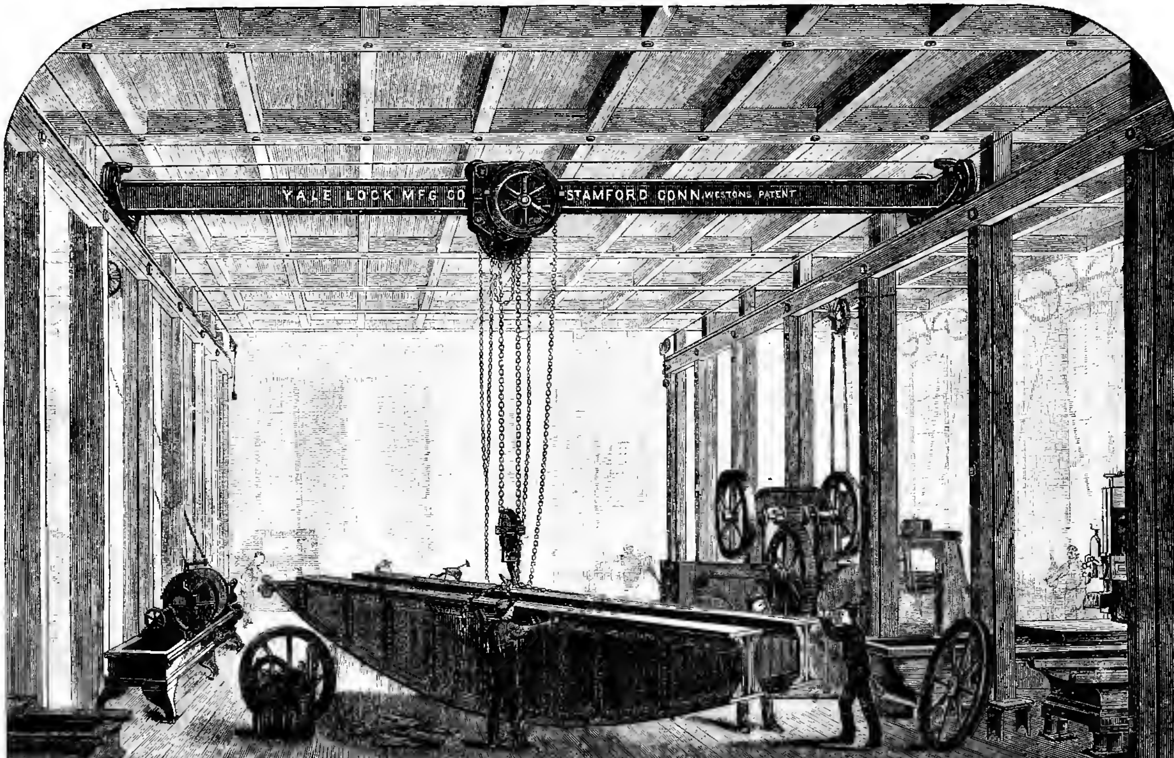


FIG. 61.—Hand Traveling Crane, with Underhung Trolley.

control the motions of the bridge upon its tracks and of the trolley upon the bridge, while the other two each effect hoisting or lowering (according to the direction in which they are pulled) at different speeds, a third speed being obtained by simultaneously using both.

The construction of the crab economizes room by placing much of the gearing between the crab frames and the bridge, thus adapting the crane to use in shops or rooms with low ceilings, where the construction shown in Fig. 60 would occupy too much height, but the latter type of crane is to be preferred wherever the head room admits of it. Reference is made to Part II for full descriptions of the detail parts of this crane.

The cranes of this pattern are designed especially for use in machine shops, both for setting work in machines and for erecting it, and also in forges, mills, stone sheds, and warehouses for the storage of heavy goods.

Estimates will be submitted on receipt of information as to the maximum load to be lifted, the span or length of bridge, height from floor to ceiling, and length of longitudinal travel.

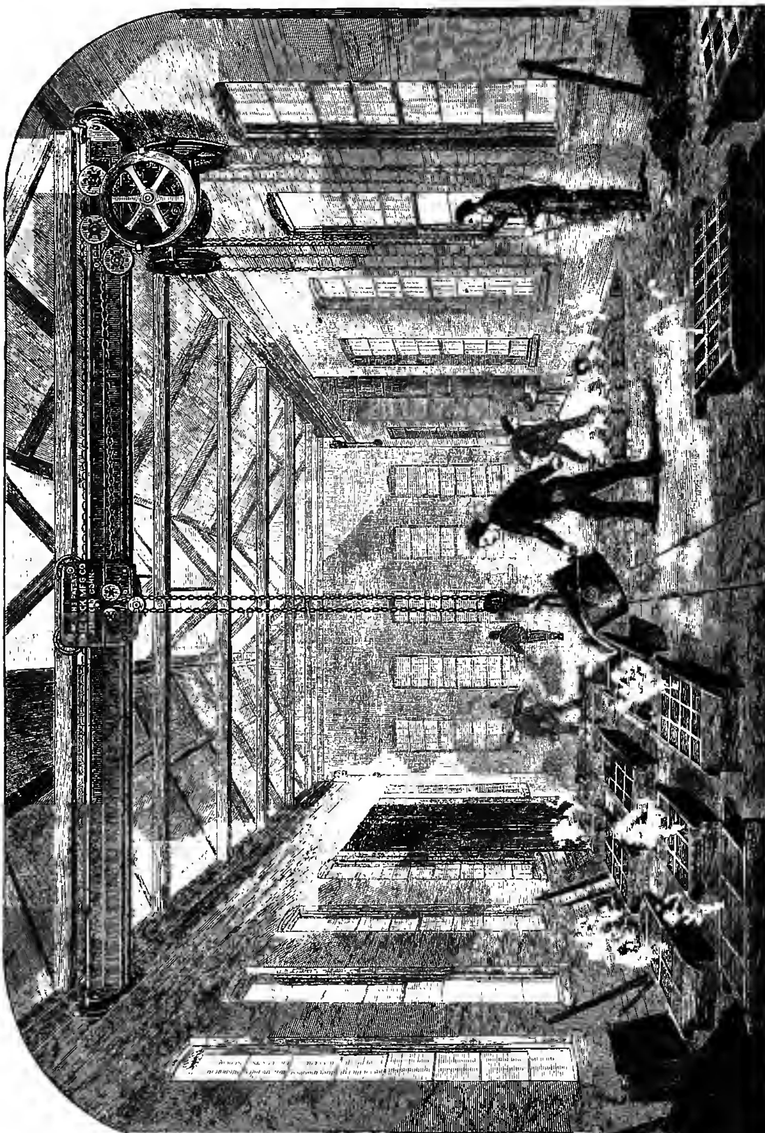


Fig. 62.—Hand Traveling Crane, with Fixed Crab.

HAND TRAVELING CRANE.

FOUNDRY PATTERN.—WITH COMPLETE HOISTING AND TRAVELING GEAR.

Fig. 62 opposite represents a complete traveling crane, for operation by hand, of a construction similar to the two preceding illustrations, but with the mechanism attached to one end of the bridge so that the operator is somewhat removed from the load, thus adapting it especially to foundry use. The bridge is arranged to travel lengthwise upon the longitudinal tracks, and the trolley to move transversely upon the bridge, so that the entire rectangular space between the tracks is covered by the crane. Cranes of this design are built of any desired capacity up to 10 tons, and of any span.

The crab containing the operating mechanism is permanently secured to the under side of the bridge at one end, and is located entirely below it, so that the bridge can be placed close to the under side of roof or ceiling. The trolley travels upon tracks on top of the bridge, and its sides extend downward close to the bridge, with the chain sheaves contained between them, thus giving the maximum amount of hoist. The Weston fixed-cable system (see Part II, page 58) is employed to effect the squaring of the bridge and its longitudinal motion upon the overhead tracks. The travel of the trolley upon the bridge is effected, by an independent mechanism, operated by an endless hand chain from the floor below, in a manner similar to that employed in the jib cranes described on page 117, the details of which are fully explained in Part II, page 65. Motion of the bridge is also effected by an endless hand chain or rope passing over another rope wheel. Pulling one side of this chain causes the bridge to move in one direction, and pulling the other causes it to move in the opposite direction. At each end of the crab, or housing con-

taining the operating mechanism, are similar rope wheels, over each of which passes an endless rope or chain. Pulling either of these in one direction causes hoisting, and in the other lowering. One is larger than the other, thus giving two speeds ; while, by pulling both simultaneously, an additional speed is obtained. The several motions of hoisting or lowering, and of moving the bridge and the trolley, may each be effected independently or simultaneously.

The hoisting gear consists of cut steel worms engaging with cut worm wheels, with provision for thorough lubrication. The main hoisting chain is endless and passes over pocketed chain wheels, by which it is driven, the arrangement of parts being such as to distribute the wear equally throughout the entire length of this chain. A safety device, consisting of automatic friction ratchets in combination with the worm shafts, is employed, so that the load is always self-sustained in any position and cannot run down. Lowering is effected by reversing the motion of the hoisting chains.

The location of the mechanism at one end of the bridge removes the operator from proximity to the load, which is of course desirable in handling ladles of hot metal, and in lifting large flasks, etc. For description of the bridge construction, see page 85, of the bridge trucks page 78, and for other details the several articles in Part II.

While particularly designed for foundry use this type of crane is equally suitable for use in forges and for many of the same purposes as the cranes illustrated by Figs. 60 and 61.

Estimates will be furnished on receipt of information as to maximum load to be lifted, span or length of bridge, height from floor to under side of roof, and length of longitudinal travel.

POWER TRAVELING CRANE.

The illustration on next page represents a Weston Traveling Crane, driven by power transmitted from a stationary source, and controlled by an operator standing on a platform suspended from the crane at one end of the bridge. The bridge is arranged to travel longitudinally upon overhead tracks, and the trolley to travel transversely across the bridge, so that the efficiency of the crane covers the entire rectangle included between the tracks, which latter may, if desired, be 400 or 500 feet, or more, in length. Cranes of this construction are built of any desired capacity from 5 to 50 tons, and of any span.

This crane consists of a bridge composed of two wrought iron girders (constructed as explained in Part II, page 83) carried at each end by a two-wheeled truck (for description see page 78) with double-flanged truck wheels having chilled treads. At one end of the bridge is a crab containing the operating mechanism, and suspended beneath this is the operating platform. Power is communicated to the crane by an endless rope, moving continually in one direction, and driven by a suitable wheel on a stationary shaft at one end of the longitudinal tracks, this shaft being driven by power transmitted in any convenient manner from a stationary engine, either directly or through the line shafting. The mechanism of the crab is such that the operator, standing upon the suspended platform, is enabled, by means of three levers, to apply the power so as to cause the bridge to travel longitudinally on the tracks in either direction, or the trolley to travel in either direction across the bridge, or to raise or lower the load. The bridge and trolley may be moved independently or simultaneously, at will.

The motions of the bridge are effected by the Weston system of fixed wire cables as explained at Part II, page 58. These

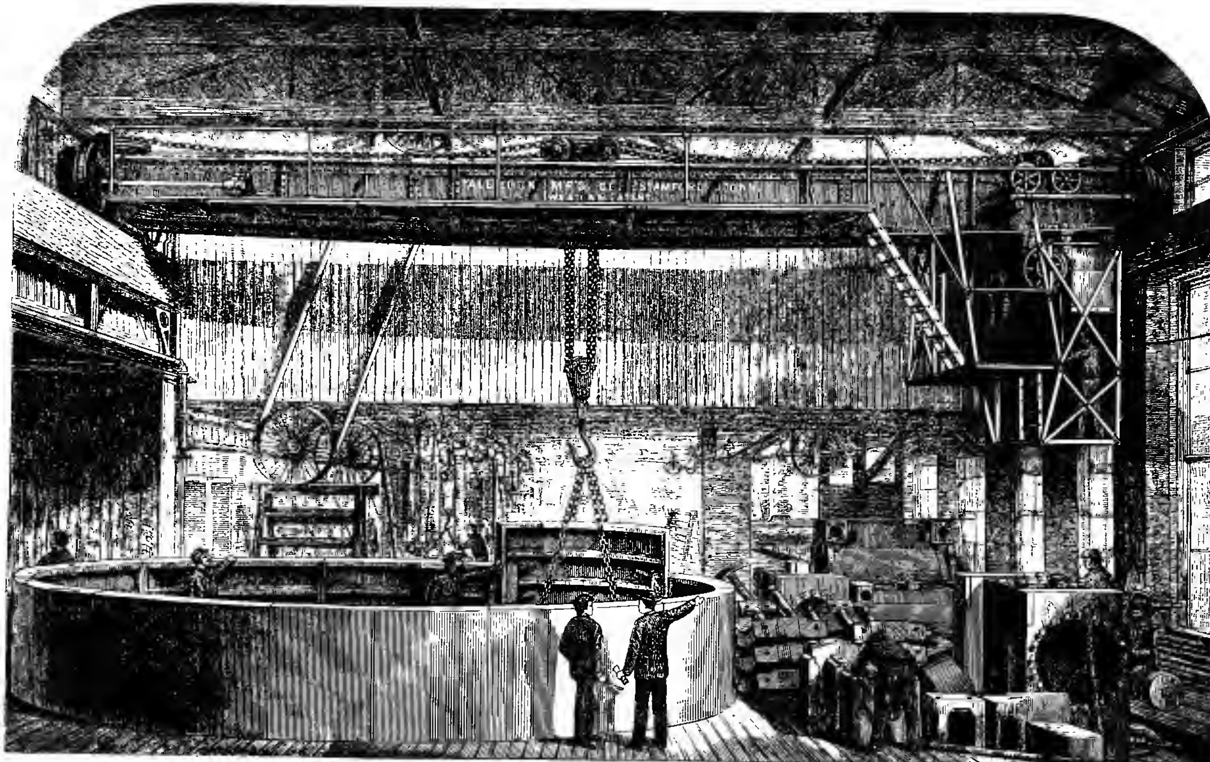


FIG. 63.—Power Traveling Crane, with Single Trolley.

cables are so arranged as to constitute a perfect squaring device, which insures the absolute parallelism of the end trucks of the bridge with their tracks under all conditions, so that the bridge always moves smoothly and with the least possible friction. The motions of the trolley on the bridge are effected through the two parts of the main hoisting chain, as explained at Part II, page 65, thus avoiding the need of an independent traversing mechanism and greatly simplifying the machine.

The hoisting and lowering gear consists of cut worm wheels with bronze rims, driven by cut steel worms running in oil, and provided with automatic devices by which the load is always self-sustained. Motion is transmitted to the worm gears by cut spur gearing, driven by the primary shaft, which in turn is driven continuously in one direction by the driving rope. The power required to effect the several motions of the machine is taken from the primary shaft by a series of Weston-Capen Frictional Disc Clutches, the details of this arrangement being described in Part II, page 73 *et seq.*, and the clutches at page 41.

Automatic stops are provided for arresting the transverse motion of the trolley at either end of the bridge, and of the bridge at either end of the longitudinal tracks, so that over-travel, either of the bridge or of the trolley, cannot by any accident occur.

Provision is always made for two speeds of hoisting and lowering, and when desired back gearing is added to the crab, thus affording four speeds of hoisting and lowering and two speeds of travel, both of bridge and trolley. When desired, hand gearing can be also added to enable the crane to be moved by hand in the event of the power being temporarily disabled. This adds somewhat to the expense of the crane and is usually not desirable, as the motions by hand are necessarily very slow and the occasions for its use very rare. The details by which the motions are accomplished are fully described in Part II at page 73.

The operating platform should, if possible, be arranged as shown in the engraving, beneath the bridge, as in this position the operator has best command of the floor below. Where the head room does not allow of this, or where other obstructions interfere, the platform can be arranged at each side of the bridge

and projecting but slightly below the crab. But, for the reason above given, this arrangement is not so good as that shown in the engraving. A foot way across the bridge gives access to the parts attached to the latter, and also to the trolley. The main chain sheaves have anti-friction bushings (see Part II, page 95) and the action is such as to distribute the wear equally throughout the entire length of the chain (see page 67).

The power traveling crane constitutes the most perfect and complete apparatus for handling heavy loads, and is to be preferred to all other types of cranes, wherever the construction of the building and the other surrounding conditions admit of its use. It avoids all strains other than vertical upon the building in which it is contained, and for its support requires merely a trestle or wall of sufficient stability to resist the direct pressure of the crane and its load, so that there is practically no limit to the capacity which may be obtained. With jib cranes, on the contrary, lateral strains upon the building are unavoidably introduced; and, where the crane is large, either in capacity or dimensions, these strains become exceedingly severe. A jib crane encroaches seriously upon the floor it covers, and its capacity for the horizontal transfer of loads is necessarily very limited. The traveling crane, on the contrary, leaves the floor below it entirely clear, and is practically unrestricted in the length of its travel. The designing of the Weston Power Traveling Cranes has been a subject of the most careful study and thorough experiment, extended over a number of years. *It is believed that these are the most highly organized and mechanically perfect cranes which have ever been built.*

Cranes of this construction are adapted for use in machine shops, forges, boiler shops, rolling mills, stone yards, and other places where heavy loads are to be handled, and where it is desired to accomplish this in the most efficient and economical manner. Where actively employed cranes of this type will do the work of from 20 to 50 men using the ordinary devices of tackles, jacks and screws, so that it is demonstrable in many cases that the economy effected by a crane within one or two years will entirely cover the cost of procuring it.

Estimates for power traveling cranes will be furnished upon receipt of information giving the following particulars, viz.: maximum load to be handled, span or length of bridge, length of longitudinal travel, height from floor to ceiling or roof, and such particulars as to the nature of the work to be done as will enable the builders to clearly understand it and to arrange the crane accordingly.

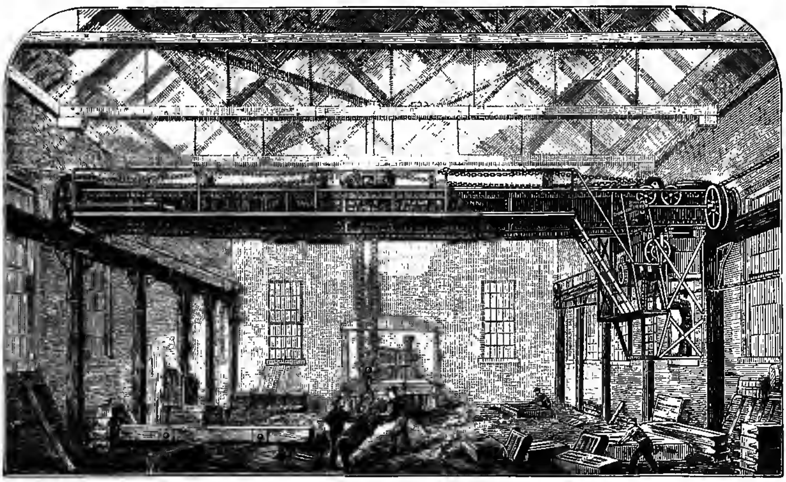


FIG. 64.—Power Traveling Crane, as applied to Foundry Use.

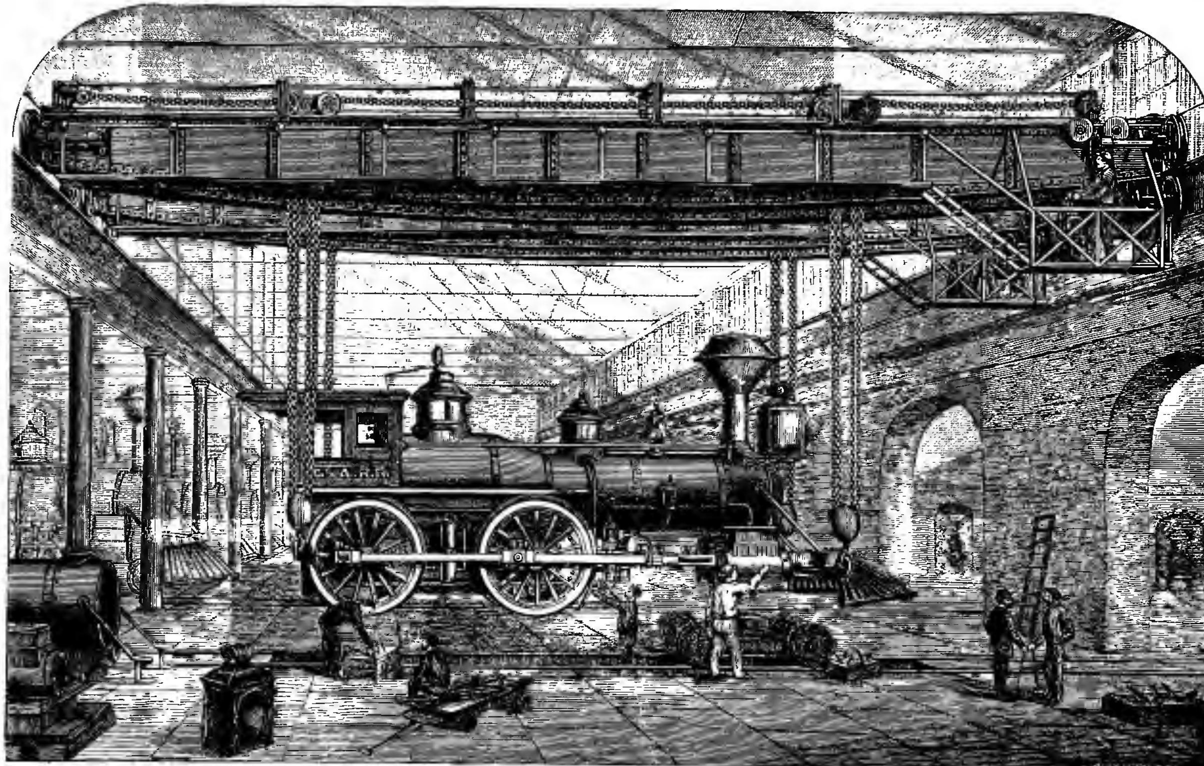


FIG. 65.—Power Traveling Crane, with Two Trolleys.

POWER TRAVELING CRANE.

DOUBLE TROLLEYS—TWO CRANES ON SAME TRACKS.

Fig. 65, on opposite page, represents a locomotive repair shop equipped with two Weston Power Traveling Cranes, running upon the same longitudinal tracks, and each crane provided with two trolleys, thus giving four running blocks and enabling the load to be suspended from four points.

The cranes used for this purpose are indentical with those shown and described on pages 155 to 158, to which reference is made for particulars as to their construction. The arrangement of the cranes herewith represented is useful in many situations. The use of two cranes upon the same set of overhead tracks is desirable in foundries, for handling very heavy castings, and in large shops for the erection of machinery and for similar purposes. Two separate machines are thus obtained, each available for use independently of the other, while for handling very heavy loads, or very long pieces of work, the two cranes can be brought together and both used simultaneously.

The arrangement of two trolleys upon one crane is less frequently required, but is desirable for such work as is represented in Fig. 65, as it distributes the strains on the bridge and enables the load to be seized at several points. In cranes having two trolleys the operating levers are doubled, thus giving the operator control of each trolley independently of the other. The addition of a second trolley is effected with but slight increase in space occupied by the operating mechanism, but necessarily adds considerably to the expense of the crane.

As shown in Fig. 65, each of the two traveling cranes is controlled by a separate operator standing upon its platform, who, as above explained, is enabled to control independently each of the

two trolleys upon each crane. The method of transmission of power assures equal speeds upon both machines, so that they may be combined, as shown in the engraving, and their united power utilized for lifting a heavy load suspended from the four blocks or tackles. At other times the two cranes may be separated, and used independently in different parts of the shop.

Wherever large loads are to be occasionally handled, and particularly where these loads consist of long pieces, as in bridge work, it is always better to have two cranes, whose combined capacity shall furnish the maximum power required, rather than one of larger size. For handling heavy loads of most kinds, the two cranes are really better than one, while at other times they afford the convenience of *two distinct machines*, each of which, being smaller and lighter than a crane of larger capacity, is better adapted for handling light loads and performing the ordinary work required of it. Where two cranes are thus combined it is not necessary that their capacity should be equal. For instance, where a maximum capacity of 25 tons is required, it is often found best to construct one of the cranes with a capacity of 15 tons and the other of 10 tons, the latter being used for the lighter parts of the work, the former for the heavier, and both cranes brought together when the maximum capacity is desired.

Estimates will be furnished for cranes arranged in the manner above explained, upon receipt of the same information as specified upon page 159.

PART IV.

PART IV.

INTRODUCTION.

In designing and building machinery for hoisting and transferring light loads, many of the same problems are presented which occur in the construction of heavy cranes, and the experience gained in one is available in the other. Too much has heretofore been left to "rule of thumb" practice in the designing of light hoisting machinery, and frequent accidents to life and limb still needlessly occur from continued adherence to old types of machines in which safety, both of person and load, depends upon the care and intelligence of the operator.

It is possible to so construct hand hoisting machinery that accidents arising from carelessness in its use are practically impossible. Such construction involves no sacrifice of simplicity or efficiency, and no material increase in cost. To adhere to the old, therefore, is to assume needless risks to property and unjustifiable risks to human life. The risks referred to arise chiefly from two causes; *first*, a deficiency of material in parts subject to strain; and, *second*, the use of ratchet wheels to hold the load suspended, and of non-automatic brakes to effect lowering. The first defect, a want of proper kind or amount of material, arises from unskillful designing and from the effort after cheapness. The second is inherent in the elements of mechanism employed, and can only be avoided by the use of new and better devices, so constructed as to be automatic in all functions where carelessness is potent to produce harm.

The active operation of *hoisting* is usually free from danger in any machine of sufficient strength. It is the *descent* of the load, whether by intention or by accident, that involves danger. During the act of hoisting the operator slowly expends power,

which is stored up as latent energy in the mass he has raised, and which, if expended or given back suddenly, as in falling, is capable of working serious mischief. The mechanism should, therefore, be so constructed that the load, when lifted, shall be sustained independently of the operator, so that, should he cease his efforts, or even suddenly let go the rope or handles, the load will simply cease to move and will remain suspended. Under no circumstances should the load be permitted to descend by gravity unaided by the controlling hand of the operator. This principle of construction, namely, the control of the load, at all times and under all conditions, by reliable automatic devices, is embodied in all of the hoisting appliances described in the following pages.

RELATION OF POWER TO SPEED.

In ordering hoisting machines, customers not infrequently ask for "great power" and "quick speed" in the same machine. That is, they call for a machine in which one man can lift a very heavy load and raise it quickly. In answer to such demands, the following explanation of the mechanical facts involved is submitted.

Power and *speed* are convertible terms. A man may with one machine lift 1,000 pounds 10 feet high in one minute, and with another machine, differently geared, may lift 100 pounds 100 feet high, in one minute. In each case the work accomplished is the same, and is expressed mechanically by multiplying the weight by the number of feet it is lifted in one minute, the result being designated "foot-pounds." In each of the above supposed cases the work accomplished amounts to 10,000 *foot-pounds.*

The average efficiency of a man working on a crank or rope is from 4,000 to 8,000 foot-pounds per minute for ordinary work. These figures can be considerably increased during short periods.

A hoisting machine can be proportioned with any ratio of gearing desired. If wanted to hoist rapidly it means that one man can lift only a small load. If wanted to hoist a heavy load it follows that one man can raise that load only very slowly.

The ratio of gearing in the various hoisting machines herein illustrated is that which experience has demonstrated to be the best and most convenient for ordinary purposes. It is always such that the maximum load for which the machine is intended can be raised at the quickest speed which is possible with the number of men employed. When desired, the ratio of the gearing can usually (at some extra expense) be varied, but it must be remembered that any gain of speed is always accompanied by a corresponding loss of power, and any gain of power accompanied by a corresponding loss of speed. It is not posssible, *without an increase in the amount of power applied to the machine,* to simultaneously increase both its power and speed.

WESTON'S DIFFERENTIAL PULLEY BLOCK.

The portable hoisting device generally known by the above name was invented some twenty years ago. It secured immediately great popularity, and its use extended rapidly throughout the civilized world, wherever modern machinery was known and appliances for lifting heavy weights were needed. No previous device had ever embodied the same conveniences, namely, great lifting power and the ability to hold the load suspended at any point, and the accomplishment of these ends by a machine of great simplicity, compactness, and of light weight. The universal adoption, throughout the world, of the Weston Differential Pulley Block as the standard type of portable hoists, is due to the fact that it perfectly meets all of these requirements and in the simplest possible way. Since its introduction other machines have been invented for similar uses, but no one of them combines in itself the important characteristics of power, safety, simplicity and portability to a degree which equals that of the Weston Block. The latter is demonstrably a reduction of the problem to its simplest possible form, and therefore can never be superseded. In recent text books it is given a place among the other mechanical powers or elements, thus recognizing the fundamental character of its design and usefulness.

The principles on which the action of the differential pulley block is based are not generally understood. They have been clearly discussed by Professor Ball, and his description of them is reproduced below.

THE DIFFERENTIAL PULLEY BLOCK.*

The principle of the differential pulley is very ancient, but it is only recently that it has been embodied in a machine of prac-

* Experimental Mechanics, by R. S. Ball, A.M., Macmillan & Co., London, 1871; page 112 *et seq.*

tical utility. In designing any mechanical power the object to be aimed at is this, that while the power moves over a considerable distance the load shall only be raised a short distance. When this object is attained we then know by the principle of energy that we have gained an increase of power.

Let us consider the means by which this is effected in that ingenious contrivance, Weston's Differential Pulley Block. The principle of this machine will be understood from Fig. 66 and Fig. 67.

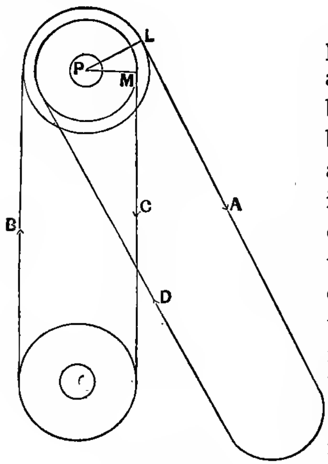


Fig. 66.

It consists of three parts—an upper pulley block, a movable pulley, and an endless chain. We shall briefly describe them. The upper block P is furnished with a hook for attachment to a support. The sheave it contains resembles two sheaves, one a little smaller than the other, fastened together; they are in fact one piece. The grooves are furnished with ridges which prevent the chain from slipping around them. The lower pulley Q consists of one sheave which is also furnished with a groove, it carries a hook to which the load is attached. The endless chain performs a part that will be understood by the arrow heads attached to it in the figure. The chain passes from the hand at A up to L, over the larger groove in the upper pulley, then downwards at B, under the lower pulley, up again at C, over the smaller groove in the upper pulley at M, and then back again by D to the hand at A. When the hand pulls the chain downwards the grooves of the upper pulley begin to turn together in the direction shown by the arrows on the chain. The large groove is therefore winding up the chain while the smaller is lowering.

In the pulley which has been employed in the experiments to be described the effective circumference of the large groove is found to be 11.84 inches, while that of the small groove is 10.36

inches. When the upper pulley has made one revolution the large groove must have drawn up 11.84 inches of chain, since the chain cannot slip on account of the ridges; but in the same time the small groove has lowered 10.36 inches of chain; hence, when the upper pulley has revolved once, the chain between the two must have been shortened by the difference between 11.84 and 10.36 inches, that is, by 1.48 inch; but this can only have taken place by raising the movable pulley through half 1.48 inch, that is, through a space of .74 inch. The power has then acted through 11.84 inches and has raised the resistance .74 inch. The power has therefore moved through a space 16 times greater than that through which the load moves. In fact it is very easy to verify by actual trial that the power must be moved through 16 feet in order that the load may be raised 1 foot. We express this by saying that the velocity ratio is 16.

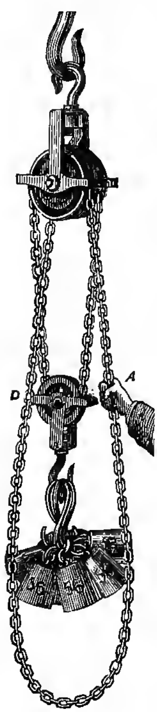


Fig. 67.

By applying power to the chain at D, proceeding from the smaller groove, the chain is lowered by the large groove faster than it is raised by the small one, and the lower pulley descends. The load is thus raised or lowered with great facility by simply pulling one chain A or the other D.

We shall next consider the mechanical efficiency of the differential pulley block. The block (Fig. 67) which we shall use is intended to be worked by one man and will raise any weight not exceeding a quarter of a ton.

We have already learned that for the load to be raised 1 foot the power must act through 16 feet. Hence were it not for friction we should infer that the power need only be the 16th part of the load. A few trials will show us that the real efficiency is not so large, and that in fact more than half the power exerted is merely expended upon overcoming friction. This will lead afterwards to a result of considerable practical importance.

Placing upon the load-hook a weight of 200 pounds I find

that 38 pounds attached to a hook fastened on the power-chain is sufficient to raise the load; that is to say, the power is about $\frac{1}{6}$ of the load. If I make the load 400 pounds I find the requisite power to be 64 pounds, which is only about 3 pounds less than $\frac{1}{6}$ of 400 pounds. We may safely adopt the practical rule that with a differential pulley block of this class a man will be able to raise a weight six times greater than he could raise without such assistance.

A series of experiments carefully tried with different loads have given the results shown in the following table:

THE DIFFERENTIAL PULLEY BLOCK.

Circumference of large groove, 11″·84, of small groove, 10″·36; velocity ratio, 16; mechanical efficiency, 6·07; useful effect 38 per cent.; formula P=3·87 + 0·1508 R.

Number of Experiment.	R. Load in pounds.	Observed power in pounds.	P. Calculated power in pounds.	Difference of the observed and calculated values.
1	56	10	12·3	+ 2·3
2	112	20	20·8	+ 0·8
3	168	31	29·2	− 1·8
4	224	38	37·7	− 0.3
5	280	48	46·1	− 1·9
6	336	54	54·6	+ 0·6
7	392	64	63·1	− 0·9
8	448	72	71·5	− 0·5
9	504	80	80·0	0·0
10	560	86	88·4	+ 2·4

The first column contains the numbers of the experiments; the second the weights raised; the third the values of the corresponding powers. From these the following rule for finding the power has been obtained:

To find the power multiply the load by 0.1508 and add 3.87 pounds to the product; this rule may be expressed by the formula

$$P=3.87 + 0.1508\ R.$$

The calculated values of the powers are given in the fourth column, and the differences between the observed and calculated values in the last column. The differences do not in any case amount to 2.5 pounds, and considering the size of the loads raised (up to a quarter of a ton), the formula represents the experiments with satisfactory precision.

Suppose, for example, 280 pounds is to be raised; the product of 280 and 0.1508 is 42.22, to which when 3.87 is added we find 46.09 to be the requisite power. The mechanical efficiency found by dividing 46.09 into 280 is 6.07.

To raise 280 pounds 1 foot, 280 foot-pounds of energy would be necessary, but in the differential pulley block 46.09 pounds must be exerted for a distance of 16 feet in order to accomplish this object. The product of 46.09 and 16 is 737.4. Hence, the differential pulley block requires 737.4 foot-pounds of energy to be applied to it in order to produce 280 foot-pounds; but 280 is only 38 per cent. of 737.4, and therefore, with a load of 280 pounds only 38 per cent. of the energy applied to a differential pulley block is utilized. In general we may state that not more than about 40 per cent. is profitably used, and that the remainder is employed in overcoming friction.

It is a very remarkable and useful property of the differential pulley that a weight which has been hoisted by it will remain suspended, without any tendency to run down; this is a point of great practical convenience. In all pulleys we have previously considered this property does not exist. The weight raised by the 3-sheave pulley block, for example, will run down unless the free end of the rope be properly secured. The differences in this respect between these two mechanical powers is not a consequence of any special mechanism; it is simply caused by the excessive friction in the differential pulley block.

The reason why the load does not run down in the differential pulley may be thus explained. Let us suppose that a weight of 400 pounds is to be raised 1 foot by the differential pulley block; 400 units of work are necessary and therefore 1,000 units of work must be applied to the power-chain to produce the 400 units (since only 40 per cent. is utilized). The friction

will thus have consumed 600 units of work when the load has been raised 1 foot. If the power-weight be removed, the pressure supported by the upper pulley block is diminished. In fact, since the power-weight is about $\frac{1}{6}$ of the load the pressure on the axle when the power-weight has been removed is only $\frac{6}{7}$ of its previous value. The friction is produced by the pressure of the pulleys on their axles and is nearly proportional to that pressure; hence when the power has been removed, the friction on the upper axle is $\frac{6}{7}$ of its previous value, while the friction on the lower pulley remains unaltered.

We may, therefore, assume that the total friction is at least $\frac{6}{7}$ of what it was before the power-weight was removed. Will friction allow the load to descend? 600 foot-pounds of work were required to overcome the friction in the ascent: at least $\frac{6}{7} \times 600 = 514$ foot-pounds would be necessary to overcome friction in the descent. But where is this energy to come from? The load in its descent could only yield 400 units, and thus descent by the mere weight of the load is impossible. To enable the load to descend, we have actually to aid the movement by pulling the chain D (Figs. 66 and 67), which proceeds through the small groove in the upper pulley.

The principle which we have here established extends to other mechanical powers and may be stated generally. Whenever rather more than half of the applied energy is uselessly consumed by friction, the load will remain suspended without overhauling.

Professor Ball then proceeds to consider other forms of self-sustaining blocks and shows that they also consume 60 per cent. of energy in friction, but that their mechanical efficiency is somewhat less than that of the Weston Differential Pulley Block. His statement that the friction in the differential block "is produced by the pressure of the pulleys on their axles," and that it is this friction alone which sustains the load, is probably incorrect. The friction of the other parts, particularly of the links of the chain upon one another and in the pockets of the chain wheels, is undoubtedly an important factor. Indeed the mere axle friction is

not much greater in the differential block than in the common rope block and obviously would not alone sustain the load. His other deductions, however, are based upon actual and careful experiment, and are doubtless correct.

The important fact which they demonstrate is that any machine of this type which automatically sustains the load by the simple friction of its parts, and without the application of a brake, can only have a mechanical efficiency of something less than 50 per cent. The mechanical efficiency of any kind of hoisting machine is probably not more than 80 to 90 per cent. of the applied power. The difference between this and the efficiency of a self-sustaining hoist (which is about 40 per cent. of the applied power) is, in the latter case, absorbed in the machine itself in order to impart to the latter the capacity of holding the load always self-sustained, so that it cannot run down, and so that the application of moderate power is necessary to effect lowering. The differential pulley block, particularly in its geared form, accomplishes these results as economically as is practicable, and possesses greater simplicity, compactness and durability than any other machine of this type.

WESTON'S

SAFETY HAND-HOISTING MACHINERY.

The following pages contain illustrations of a variety of hand-hoisting appliances, all of which are so constructed that the load is always self-sustained and cannot run down, thus guarding perfectly against accidents, either to the load or to the operator. They are all of them essentially "safety" appliances.

The construction of the differential pulley block, and the principle on which its self-sustaining feature is based, is fully explained in the preceding article. The action of the "double lift" hoist is explained in Part II, page 34. The safety hoist crab and winch, each contains, in one form or another, a frictional safety ratchet, the principle of which is explained in Part II, page 33. The general construction and mode of action of each of the several machines is described in connection with its illustration.

FIG. 68.—"Direct" Block.

WESTON'S "DIRECT" DIFFERENTIAL PULLEY BLOCKS.

One man can lift 1,000 lbs.
They hold the load at any point, and cannot run down.
Lifting and Lowering effected by pulling opposite sides of the slack chain.

SIZES OF DIRECT BLOCKS.

Capacity.	Regular Length of Chain.	Hoist. See note.*	Net Weight. Complete.
1/8 Ton.	18 ft.	5 ft.	11 lbs.
1/4 "	22 "	6 "	22 "
1/2 "	26 "	7 "	30 "
1 "	30 "	8 "	51 "
1 1/2 "	33 "	8 1/2 "	81 "
2 "	36 "	9 "	122 "
3 "	38 "	9 1/2 "	173 "

*NOTE—Figures in third column denote approximate height which blocks, with regular lengths of chain, will hoist from level on which operator stands. For greater length of hoist allow about four feet additional of chain for each foot of extra hoist.

These are the most simple and compact blocks ever devised, and are recognized all over the world as the standard type of portable hand-hoisting machine. They are a finality, for the reason that they solve the problem with what is demonstrably the fewest possible number of parts and the greatest possible simplicity, both of form and action.

WESTON'S "GEARED" DIFFERENTIAL PULLEY BLOCKS.

Fig. 69.—"Geared" Block.

One man can lift from 2,000 to 5,000 lbs.

They hold the load at any point, and cannot run down.

Easy and smooth in action—compact and convenient to handle.

SIZES OF GEARED BLOCKS.

Capacity.	Regular Lengths of Main Chain. Main Chain.	Hand Chain.	Hoist. See Note.*	Net Weight. Complete.
1 Ton.	22 ft.	16 ft.	8 ft.	62 lbs.
2 "	24 "	18 "	9 "	109 "
3 "	26 "	20 "	10 "	159 "
4 "	28 "	22 "	11 "	257 "
5 "	30 "	24 "	12 "	324 "
6 "	32 "	26 "	13 "	493 "
8 "	36 "	28 "	14 "	735 "
10 "	40 "	30 "	16 "	1054 "

*Note.—Figures in fourth column denote approximate height which Blocks, with regular lengths of chain, will hoist from level on which operator stands. For greater length of hoist, allow 2½ feet of Main Chain, and 2 feet of Hand Chain for each foot of extra hoist.

These blocks have all the merits of the "Direct" blocks shown on the preceding page, with the addition of a small train of spur gearing, driven by a separate hand chain, thus affording two powers, or changes of speed, and greatly increasing the lifting power of the operator. The action is smoother than that of the direct block, and the length of the hand chain does not vary.

WESTON'S SAFETY "DOUBLE LIFT" HOISTS.

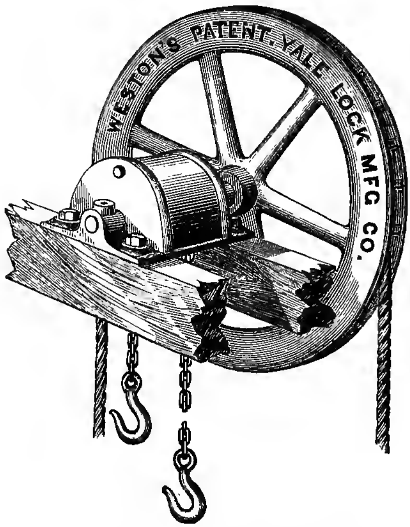


FIG. 70.—Direct "Double Lift" Hoist.

This simple and convenient little machine is intended especially for use over hatchways and in similar places, and is made in capacities from 500 to 2,000 pounds. Fig. 70 shows the smallest size, which is without gearing. The larger sizes are geared, as shown in Fig. 71. It is also made in its smallest size, in portable form and has a quicker action than the differential block.

The "Double Lift" consists of a chain, with a hook on each end, passing over a sheave which can be rotated by the hand rope and wheel. Pulling one side of the rope causes the opposite side of the chain to rise with the load. Pulling the other side of the rope causes the load to descend, but only as fast and as long as the rope is pulled. If the rope is let go the load will remain suspended; it can never run down. As one hook ascends the other descends and is thus ready for the next load.

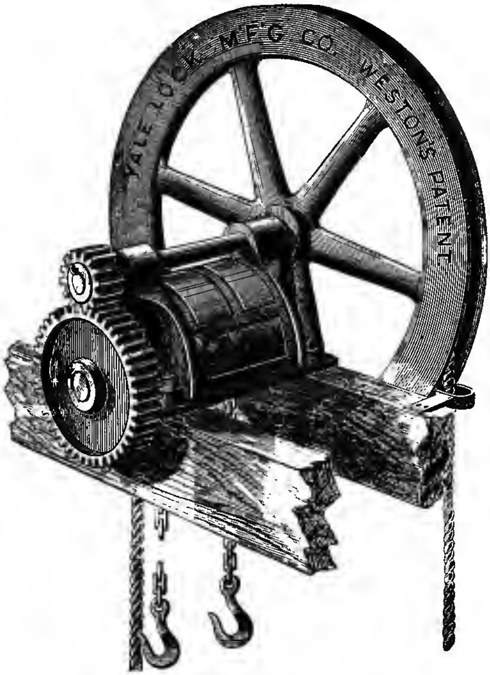


FIG. 71.—Geared "Double Lift" Hoist.

This is a better, safer and simpler machine than the old "rope wheel and drum" so commonly used. The construction of its parts by which the self-sustaining action is obtained is described in Part II, page 33, to which reference is made for further particulars.

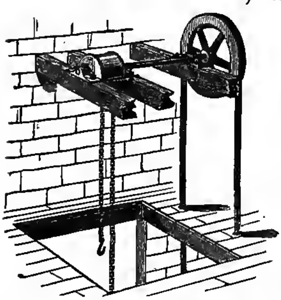


FIG. 72.—"Double Lift," as used for Hatchway.

Fig. 72 shows the "Double Lift" as used over a hatchway, with its shaft extended so as to bring the rope wheel beyond the line of the opening. Its application to light cranes is shown on page 186.

WESTON'S "SAFETY HOIST."

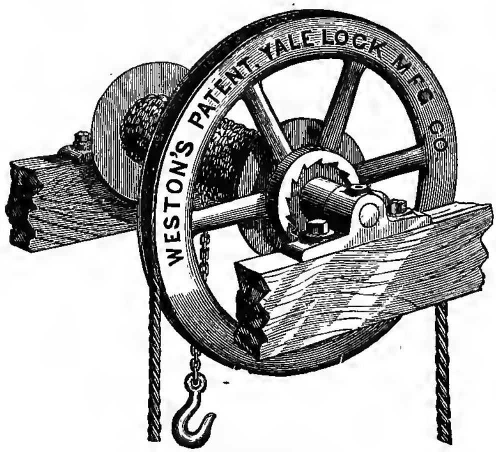


FIG. 73.—"Safety Hoist."

The "Safety Hoist" consists of an ordinary barrel or drum, on which the hoisting rope or chain is wound, and a grooved wheel for the hand rope, the purchase or power being obtained by the difference in diameter of the wheel and barrel.

The safety device consists of a friction ratchet similar to that shown in Fig. 5, page 36, but without any friction discs. Its effect is to hold the load always self-sustained. Lowering is effected by pulling the hand rope in the contrary direction to that for hoisting, and is made rapid by imparting due velocity to the fly wheel; but as the fly wheel loses its momentum and comes to rest so also does the load; the self-sustaining feature being constant in action and inseparable from the construction.

This machine is made of capacities of from 250 to 400 pounds, and with various lengths of barrels, according to the height of hoist.

WESTON'S "SAFETY HOIST,"

WITH "GOVERNOR" ACTION.

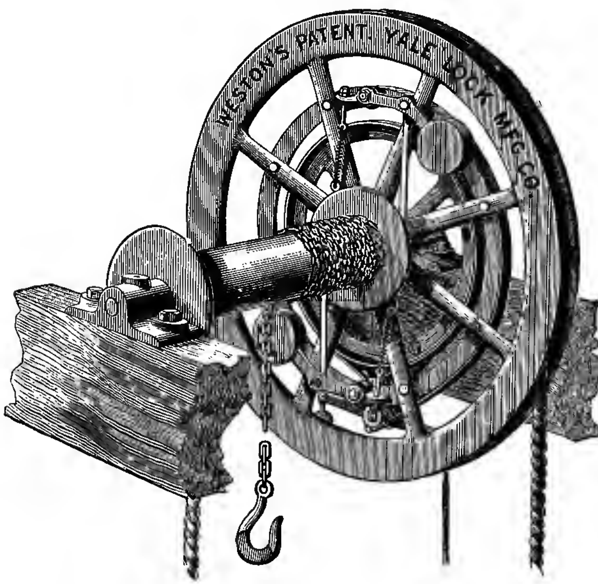


FIG. 74.—Governor Hoist.

This machine is identical with one previously described, except that it has added a "governor" for controlling the speed of the load when lowering, so that the load is allowed to descend *by gravity*, under the control of the governor, and without assistance from the operator.

Where much *lowering* of goods is necessary, it saves the time of one man and often enables a boy to be substituted. The load, once started downward, takes care of itself while the operator gets his next load ready. The governor attached to the

rope-wheel automatically controls the speed of descent, whether the load be light or heavy, and the construction is such that the desired rate of speed may be easily varied by the adjustment of a screw.

The illustration shows the governor as applied to a Weston "Safety Hoist." It is also capable of attachment to shafts of any kind for the purpose of governing their speed and guarding against excessive velocities.

WESTON'S HOISTING CRAB,

WITH AUTOMATIC SAFETY BRAKE.

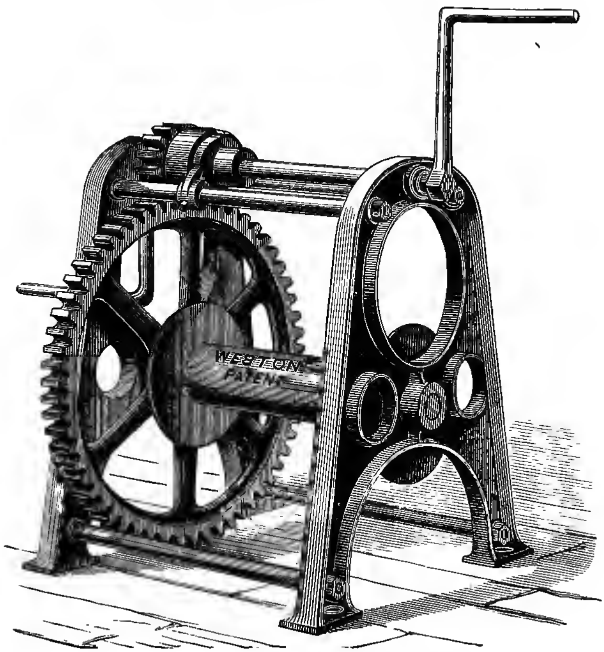


FIG. 75.—Safety Crab.

The crabs and winches illustrated on this and the succeeding page, consist of the usual winding barrel, for common rope or chain, driven by manual power, applied to cranks, through two or more spur wheels, the ratio of the gearing being varied in the several sizes of machines, according to the load to be lifted.

The *lifting* is accomplished in the usual manner. The *lowering* is done with the least possible exertion, by winding the handles backwards, and as long as this motion is continued the load will descend. The safety ratchet or brake is of the type illustrated by Fig. 5, page 36, and its construction such that the load is always self-sustained and cannot run down. *The*

WESTON'S DERRICK WINCH,

WITH AUTOMATIC SAFETY BRAKE.

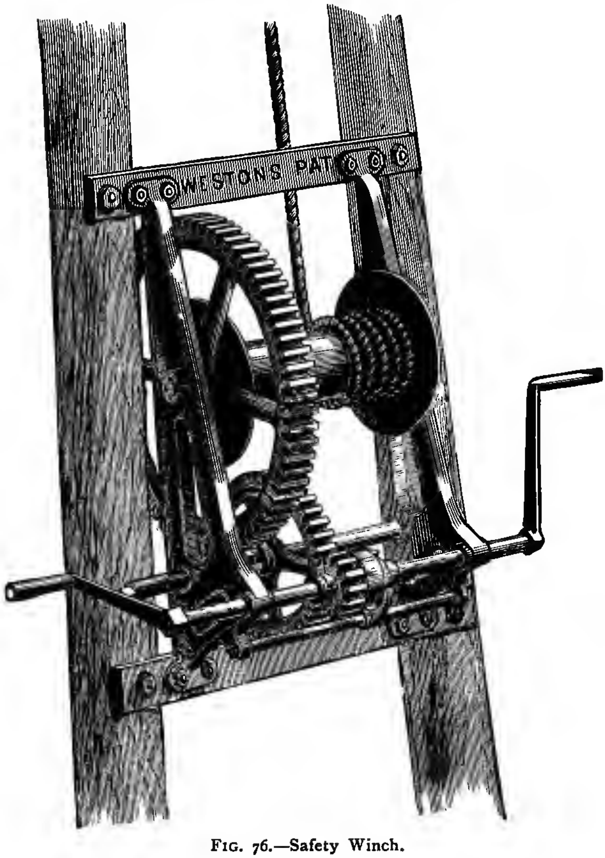


FIG. 76.—Safety Winch.

handles cannot recoil on the operator, and if suddenly "let go" at any time, either in hoisting or lowering, the load will quietly come to rest and remain suspended.

The smaller size has only a single speed or power; the larger size, two changes of speed. The capacity of either may be increased by the use of a running block in the usual manner.

WESTON'S DREDGING WINCH,

FOR OYSTER BOATS, YAWLS, ETC.

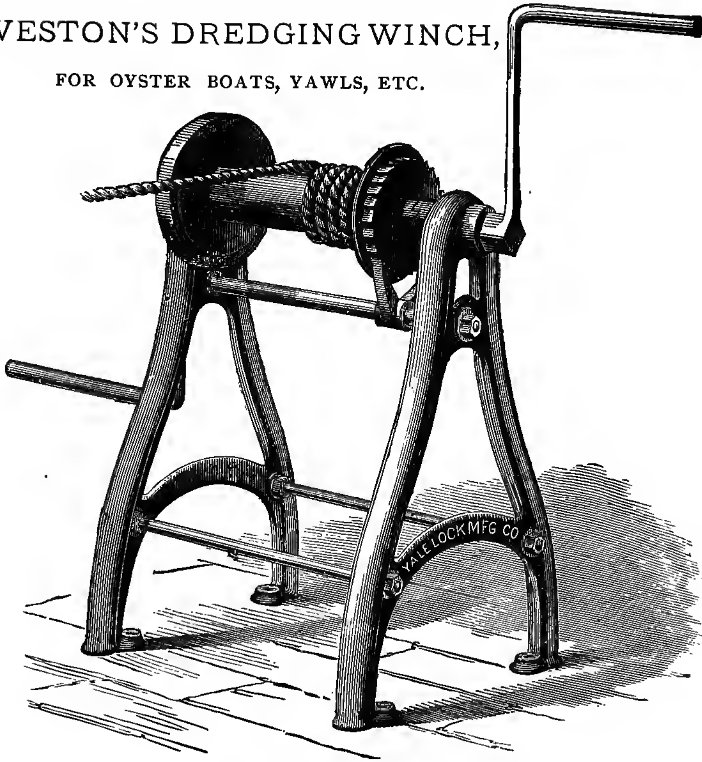


Fig. 77.—Safety (Slip) Winch.

This is a small winch, for hauling in a light rope or chain, provided with a friction brake or clutch so adjusted that if the strain on the rope exceeds a certain limit, the brake will *slip* and permit the rope to pay out by unwinding the barrel.

In dredging, the clutch is set so as to give a pull sufficient to lift the usual load, but to slip if this load is exceeded, so that, by means of this slipping, the bow of the boat is free to rise to the seas, even if the grapple has seized too large a load, or is foul of the bottom. The operator can thus safely retain his hold of the cranks, even in the roughest water, without danger of injury to himself or of swamping his boat.

LIGHT SWING CRANE,

WITH WESTON'S "DOUBLE LIFT" HOISTING GEAR.

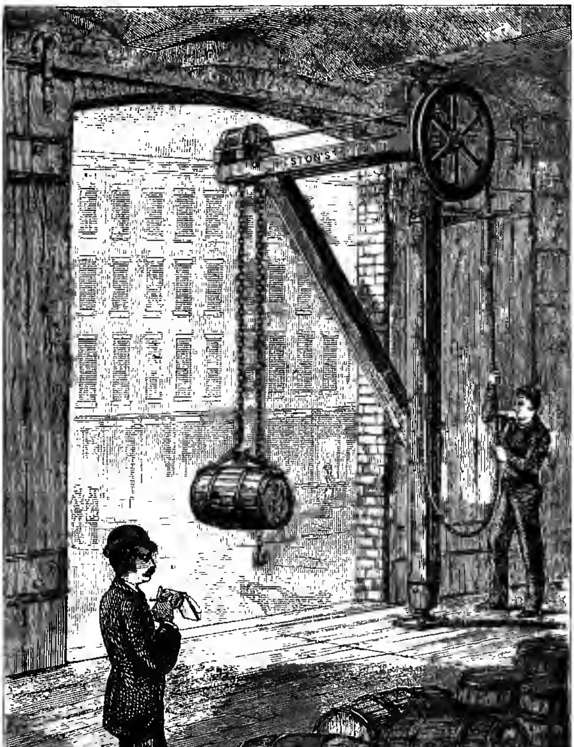


FIG. 78.—Light Swing Crane.

This crane consists of a neat wooden frame, turning in iron bearings at top and bottom, and provided with a hoisting gear consisting of a double lift, as described on page 178. It is built of capacities from 500 pounds to 2,000 pounds, and is a simple, safe and convenient machine for light work.

OVERHEAD TRAMRAILS.

SINGLE RAIL.

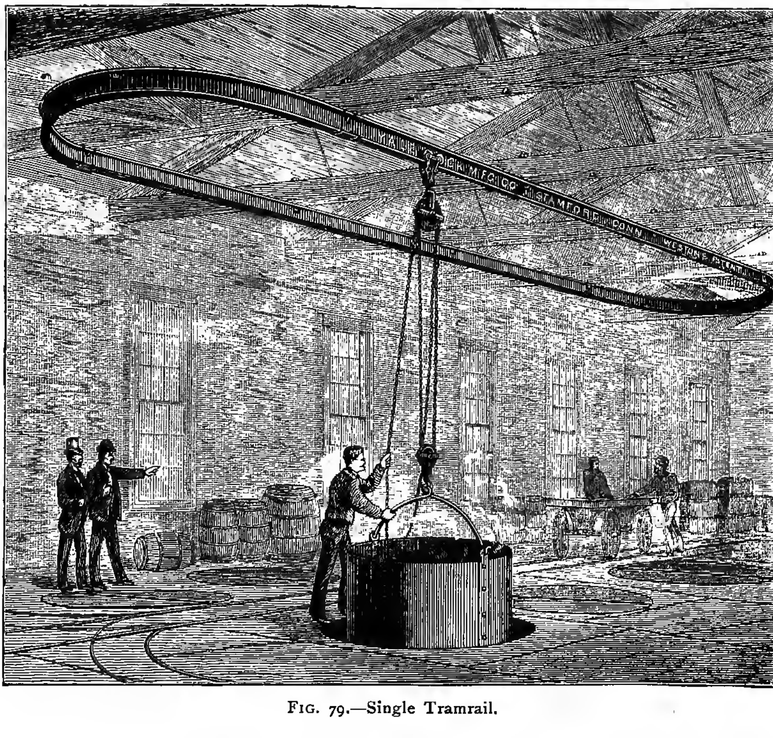


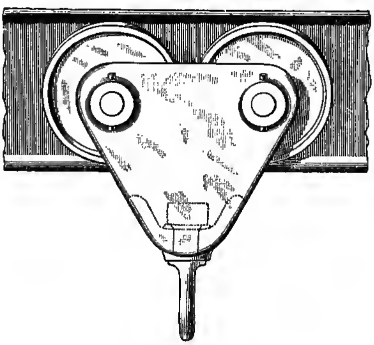
FIG. 79.—Single Tramrail.

Fig. 79 represents an employment of the differential pulley block, in combination with an overhead rail and a trolley, which is applicable to a wide range of uses, and by which at slight cost great economy can be effected in the handling of moderate weights of all kinds.

The track employed for this purpose consists of light

I-beams, which can be easily curved and for which special forms of hangers, fish-plates, bolts, etc., have been designed, and which are also provided, where necessary, with switches and turn-tables.

The trolley is arranged to run freely on the lower flange of the tracks, and is provided with four wheels or rollers, two on each side. The axles of these wheels are inclined at such an angle that the bearing of the wheels coincides with the angle of the flange of the I-beam, so that the wheels roll easily on the latter without wear or undue friction



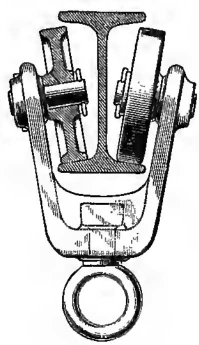


FIG. 80. Patent Trolley. FIG. 81.

Fig. 80 is a side elevation and Fig. 81 is and end view of an overhead tramrail and trolley, showing clearly the arrangement of the several parts. The construction of the fish-plates, hangers, etc., is such that they avoid all interference with the passage of the trolley, and thus permit the track to be extended to any desired length, while by means of switches and turn-tables it can be carried to any desired points within a building or yard, and be made to cover the entire area of a warehouse or works. In short lengths, tracks of this kind are particularly useful over large lathes, planers and other machine tools to assist the workmen in handling heavy pieces of work.

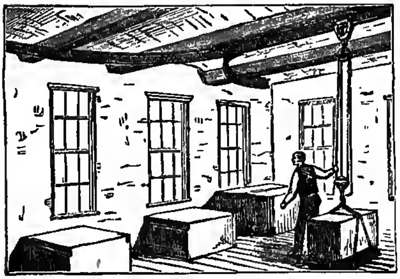


FIG. 82.—Single Tramrail, with Switch.

These tramrails are built of capacities for handling loads of all sizes. The usual capacities are from 500 to 2,000 pounds, but they have been built of sizes to handle loads up to 10 tons. They are applicable to a wide range of uses, the precise construction and arrangement varying greatly according to the work to be done.

OVERHEAD TRAMRAILS.

COMPOUND RAILS.

FIG. 83.—Compound Tramrail.

Fig. 83 represents another application of the system of overhead tramrails or transfer tracks. The arrangement shown in Figs. 79 and 82 admits of motion in one direction only, that is longitudinally upon the rail.

The arrangement shown in Fig. 83, on the contrary, consists of two parallel rails, supported from above, with a light bridge or

traveler running upon them, and this in turn provided with a trolley, so that the bridge can be moved longitudinally upon the rails, and the trolley be moved transversely on the bridge. By means of the compound motion thus obtained the entire space included between the two overhead tracks can be reached.

Fig. 83 shows this system as applied to a warehouse or packing room, and represents four pairs of overhead tracks, each carrying an independent bridge, so that the entire floor of the warehouse is covered by the apparatus. In this case the hoisting appliance consists of a portable "Double Lift" (see page 178) attached directly to the trolley, which moves on the bridge. This form of hoist is the best where the loads to be handled do not exceed 500 lbs. For larger loads the differential pulley block constitutes the best device. Special designs of hangers, bridges, trucks and trolleys have been devised in the development of this system of handling merchandize, the details of which need not be here described. The system has already been extensively adopted with most satisfactory results, the economy resulting from its use in some cases defraying the cost of erection within the first year or two.

CHANGE OF CORPORATE NAME.

The stockholders of the Corporation heretofore known as THE YALE LOCK MANUFACTURING COMPANY, at their annual meeting held April 19th, 1883, voted to accept the authority given them by an act of the Legislature of Connecticut, to change the title of the Corporation to THE YALE & TOWNE MANUFACTURING COMPANY, by which latter name it will hereafter be known.

The change is one of name only, and affects neither the property and franchises, nor the obligations of the Company. It has become desirable by reason of the greatly enlarged scope of the Company's business, in which the manufacture of LOCKS, under the Patents of LINUS YALE, JR., and others, is now only one of several large departments, the tendency of the old name being to mislead customers as to the scope of the business and the facilities of the Company for its transaction.

During the past seven years the Company has gradually built up a large business in HOISTING MACHINERY, under the Patents of THOS. A. WESTON and others, including CRANES of all kinds and of the largest sizes, and has recently also undertaken the manufacture of the "EMERY" TESTING MACHINES. The production of work of this class involves the use of large and heavy machinery, and constitutes a branch of work entirely distinct from that included in the Company's Lock and Hardware Department. Another department has been organized for the manufacture, under the Patents of A. H. Emery, of SCALES of all kinds, and of PRESSURE GAUGES, the development of which will in time, it is believed, make this department of at least equal importance with the older ones.

It will thus be seen that the business of the Company embraces not only the manufacturing operations contemplated under its original organization, but also several important lines of heavy engineering work. The buildings, machinery and appliances for the latter are already provided and in full operation, and the change of name above announced is chiefly to avoid the misunderstanding, as to the Company's business and facilities, which experience has shown to result from the limiting word "LOCK," in the old title. The ownership and management of the Company remain unchanged.

For reasons not necessary to enumerate, it has been found expedient to effect a subordinate organization, under the general laws of the State, bearing the old title of THE YALE LOCK MANUFACTURING COMPANY, and also a similar organization entitled THE WESTON CRANE COMPANY. In like manner THE EMERY SCALE COMPANY was organized in 1882. The stock of all of these subordinate companies is owned and controlled by the parent company, now known as THE YALE & TOWNE MANUFACTURING COMPANY, and although the several subordinate organizations will be permanently maintained, for purposes relating to the ownership of patents and other franchises, the business of all will be conducted by THE YALE & TOWNE MANUFACTURING COMPANY, in its own name and for its own account, so that all communications should be addressed to the latter name.

CATALOGUES.

THE WESTON CRANE COMPANY'S products are presented in this book. Prices on application.

THE YALE LOCK MANUFACTURING COMPANY'S numerous products are embraced in the following several catalogues, each devoted to a distinct specialty, any of which will be sent on application, viz.:

A.—The "Yale" and "Standard" Locks.

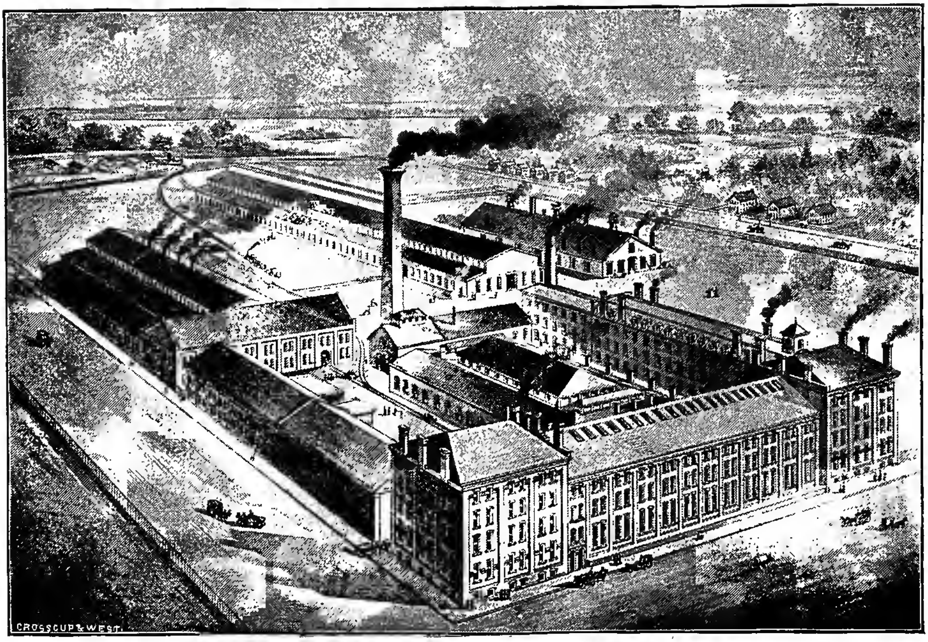
B.—Post Office Equipments.

C.—Prison and Asylum Locks.

D.—Time Locks.

E.—Combination Bank Locks.

THE EMERY SCALE COMPANY'S products will be presented by catalogue as rapidly as they are placed on the market. Orders can now be executed for "EMERY" Testing Machines, full information concerning which will be given on application.



WORKS OF THE YALE & TOWNE MANUFACTURING CO.,

ESTABLISHED, 1851. INCORPORATED, 1868.

STAMFORD, CONN.

The Works of the Yale & Towne Manufacturing Company, which are illustrated in the above engraving, are located at Stamford, Connecticut, on the line of the New York, New Haven & Hartford Railroad, thirty-four miles from New York. Thirty-eight trains pass daily in each direction between the two points, the express trains making the run in *fifty minutes*, so that a visit from New York and return can be accomplished in a few hours.

The numerous buildings are constructed entirely of brick, and are exclusively devoted to the Company's business. The general offices, drafting room, etc., are located in the front corner building, which is in great part fireproof. The other buildings include the brass and iron foundries, forges, chain shop, pattern and wood working shops, machine shops for various kinds of work, and numerous rooms devoted to light manufacturing. Railroad tracks run through the yard and connect with the railroad system of the country, while water communication is also obtained at the point indicated in the background. The works give employment to about 700 operatives.